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## Advances in Technology Enhanced Learning

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# Advances in Technology Enhanced Learning



TEL Map

Fridolin Wild, Paul Lefrere, Peter Scott



**Welcome to  
the future**

**Login**

A hand is holding a blue rectangular card with the word "Login" written in white. The background shows a person wearing a white lab coat, suggesting a medical or scientific setting.

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Europe's future lies in its people, in the way we maintain, nurture and increase our intellectual capacity. Learning in the 21st century is increasingly required to be personalised, flexible and available anywhere, anytime and technology can play a key role in meeting these goals. However, to be effective, we need to understand how and where learning is best mediated by technology - by which technologies and in which contexts. Under the 7th Framework Programme for research (FP7) the European Commission has co-funded research projects that have taken up this challenge, working at the intersection of technology and computer sciences, pedagogy and cognitive sciences. They have tackled learning in school, at the workplace, targeting learners of all ages and across different subjects. This book produced by the TEL-MAP project and published in both print and as an e-Book by the Open University sets out the roadmap and challenges for learning and presents the results of a number of large-scale projects reflecting the multidisciplinary nature of this research and the wide range of learning contexts where it can be applied. It sets the scene for all stakeholders - educationalists, employers, policymakers, teachers, students - to take stock of how we learn today and to reflect on how we can use technology to change the way we learn not only today but tomorrow.

Pat Manson

*Head of Unit*

*Inclusion, Skills and Youth*

*EUROPEAN COMMISSION*

*CONNECT Directorate-General*



# Introduction

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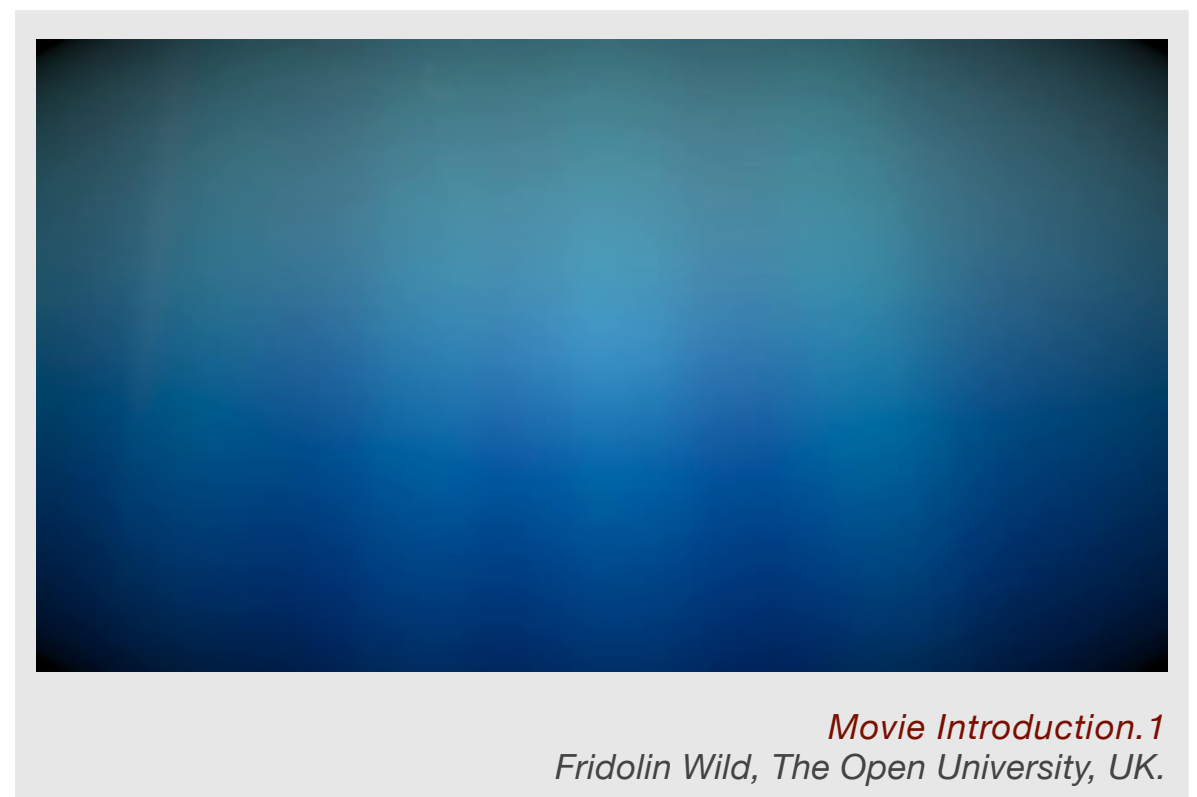


The projects described and analysed here are from some of Europe's leading researchers into and adopters of high-impact innovations in learning with technology. Much of the funding for their work has come from public sources, especially funding from the European Commission, in a series of calls for proposals within a larger framework: building Europe's capacity to innovate, and to increase its standing as one of the world's leading knowledge regions.

One obvious challenge for funders is to ensure that funding allocations are well-judged. This implies evaluation of the effects of past investments in this area in terms of impact on learners, society, and on the overall competitiveness of the economy in the involved regions. It also implies having some way to make informed decisions about coming challenges, such as required when re-organizing or even cutting costs of traditional education and training, reducing investments in one area to make space for new topics and approaches in another. Moreover, this involves assessing the likely timetable needed for developing solutions to such challenges.

The classic way to gather this intelligence on past experience, future needs, and likely solutions is to create so-called 'road maps' for each area of need and each enabling technology. Combinations of road maps from different areas can then be created and compared, to assess the scope for exploiting research results in other areas. But even with the aid of well-informed road maps, sometimes research stays in the lab, rather than being adopted as widely as hoped by its sponsors.

North American experience, partially echoed in Europe (where more public support for transfer is usual), is that as often as not, innovation in learning with technology that emerged from one setting fails to cross the 'chasm' to others, effectively limiting the scale of its application (Dede, 2006; Moore, 2002). Adaptors need to have a high level of 'absorptive capacity' in order to appropriate insights of flagship innovators (such as listed on regular basis in Educause: see, e.g., Oblinger, 2012).



This scale-limitation has a considerable bearing on the validity of roadmaps for the likely direction, timing, and impact of research on practice of learning with technology. In particular, a crucial element in that ability to cross the chasm seems to be the track record of researchers and the research institutions they are part of. Success in scaling depends on factors such as the kinds of social networks the key researchers belong to.

For example, few EU researchers have as extensive links as their US counterparts to venture capitalists or other sources of financial sponsorship that can provide the necessary basis for supporting commercial take-up beyond initial research funding. Success also depends on factors such as the scale of operations. For example, well-founded research laboratories are able to operate on sufficient scale to support projects beyond public funding. They can provide prospective adopters of research findings with further support, ranging from simply responding to additional queries about the research conducted up to extended consultancies on implementation of outcomes.

Market-led analyses too often miss out on assessing the characteristics of the research communities involved to uncover such information, although it would be relatively easy for the analysts to extract this from the websites of key researchers and their research centres or from public data available about impact of research such as collected for the UK's research excellence framework.

*“best-of selection of innovative outcomes of a set of ten large-scale, collaborative projects funded by the European Commission”*

Within this contribution, we therefore extract key recommendations from the current work of high-impact researchers of major labs that are linked to large-scale take-up. This is a best-of selection of innovative outcomes of a set of eleven large-scale, collaborative projects funded by the European Commission in the 7th Framework Programme for Research and Development with the aim of supporting practical uptake of their findings and generalising that support model to use it elsewhere.

The breadth of the work presented here was deliberately chosen in order to cover a sufficiently wide range of research, the outcomes of which are applicable to the most pressing challenges faced today in using technology in support of learning.

This contribution not only highlights the most significant aspects of each of the projects' outcomes: the tools, systems, processes, and other resources that each project offers. It also lays the foundation for developing a common frame of reference to allow for coordinated cataloguing of such project outcomes in the future ex ante and with the timeline of their delivery, possibly supported by a shared ontology.

The purpose of devising and using such a common frame of reference is to make it easier to identify potential synergies with regards to the outcomes and timing of different projects. This would enable project champions to work systematically and in concertation with other publicly-funded research projects to consider how the outputs of one project might be used in combination with the outputs of another project.

The aim is to identify possible synergies, potential cost-savings, reducing the cost of adoption, etc., and to use those discoveries to develop attractive solutions to challenging and important problems facing education and training institutions and their beneficiaries such as employers and individual learners.

Collaboration of that kind has been found useful in past projects to develop breakthrough products and services: the original Sony



Walkman for example, where individual roadmaps for innovations in unconnected areas were compared and where it became evident to Sony's CEO that the innovations involved would become ready in time to be combined into a portable device – a classic example of an 'intercept strategy'.

Road maps for innovation in technology-enhanced learning in individual subject areas have that potential to be overlaid to look for new combinations. This maximises chances for take-up, diffusion, and application of individual breakthroughs from research to learning with technology.

Other than many innovations that happen 'in the wild', the projects we turn to below present a series of calculated breakthroughs on how we deal with knowledge through technology in particular application areas such as workplaces, schools, or universities. Each of the eight integrated projects screened builds on the state of the art, but pushes the envelope by merging, migrating, and transforming existing practice and infrastructure, effectively laying the foundations for a new generation of learning technology that may cause current roadmaps to be re-written.

Other than many innovations that follow a 'research-then-transfer' approach (Glass, 1994), each of these projects subjected their developments to both representative and challenging validation studies conducted in not just a single, but a set of complementary environments.

The outcomes presented here are not only ready for the market, but also tested in the market. They bear the potential to significantly shape the near future of learning with technology on a horizon of the next few years. They are well-suited candidates to cross the chasm.

The analysis of the contributions of the two networks of excellence STELLAR and GALA goes further. Both projects help integrating the various perspectives presented into a 'bigger picture', while at the same time providing a more long-term vision and while helping build

the required capacity to deliver on a European scale. Finally and on a methodological level, we provide recommendations for improved process support in institutionalising innovation. We hope that each recommendation in isolation and the set as a whole provide a rich description and understanding of Technology Enhanced Learning (TEL) research and development of the recent years.

In the subsequent analysis, we will summarise the key outcomes of these projects along two main dimensions: what is the innovation and who are the innovators behind it. With respect to the first one, the innovation, we focus on the main technologies proposed that enhance research and practice, emphasising thereby what we regard as novel and stressing what is backed up by evidence. Looking at the second, the innovators, we extract recommendations for key actors, technologies, and processes that served well as activators of innovative research and practice. Methodologically, we conducted this analysis by applying a grounded theory approach (Glaser and Strauss, 1967).

This synthesis tells the story of what a desired state for technology and knowledge is – on a European scale. Ultimately, this summary maps out where the world is today and where it needs to go by defining desired future scenarios from the perspective of the most recent EU projects in Technology Enhanced Learning.

## Recommended key innovations

For simplicity, we make an artificial distinction between wholly methodological and wholly technological innovations. Thereby, methodological innovations refer to innovations that change the status quo of practice (plus in some cases additionally of the goals), whereas technological innovations refer to innovations that change involved tools (and in some cases may inflict changes in the wider infrastructure). Actual innovations contain a mixture of these and in most cases include some use of current-day methods and technology investments. With respect to the more methodologically-oriented innovations identified, the following can be said.

De Jong (2013) presents the advantages of a new approach to learning called “Learning by Design”, which incorporates principles of inquiry and collaborative learning. This is the result of the Science Created by You (SCY) project that offers students the opportunity to co-create solutions for real socio-technical projects. Learning by design implies learning about domain knowledge, learning about the inquiry process, and learning about cultural aspects and cultural differences that may affect the identification of effective solutions to complex socio-technical issues. Learners’ collaboration is built around sharing, exchange, and co-creation of emerging learning objects. The main advantages of inquiry-based and collaborative learning approaches like “learning by design” are: increasing student motivation, promoting

learning outside the classroom and strengthening students’ social and collaborative skills. Learning to collectively solve real-world problems also prepare students to teamwork and provides them with an authentic overview of potential job opportunities, thus bridging the gap between formal education and workplace.

**Facilitate ‘learning by design’, build inquiry-based, collaborative learning processes that are centred around ‘emerging learning objects’ (co-)created by the learners themselves.**

**Provide teacher dashboards for improved support of orchestration of learning.**

A key factor for delivering effective “learning by design” solutions is enabling flexible and customizable “orchestration”. Orchestrating learning is important to ensure learning adaptation to changes in needs and context along the learning process and this adaptation can be self-regulated by the learners or managed by the teacher. A ‘dashboard for teachers’ is an example of such technological innovation that enables teachers to better orchestrate learning. A teacher dashboard enables teachers to see the development of students in their group, decide on whether to tweak or scaffold the learning process, or whether to directly interact with a student. This implies that the learning process becomes an evolving process that can dynamically change depending on the circumstances. Warnings and feedbacks are the main hints for suggesting learners to change their behaviour and advanced Learning Analytics can provide these.

Pammer et al. (2013) describe the key results of the MIRROR project. Reflection is considered a key learning mechanism to enable self-regulated learning. MIRROR aims to facilitate reflective learning by providing a framework and toolkit for capturing learners’ experiences from real situations and “providing [these] captured data as a basis for future reflection”. Specific apps from the MIRROR toolkit help users improve time management and work performance by identifying and reflecting on actual behavioural patterns. Work activities and identified performance levels are represented back to the employees, allowing

**Capture data on actual learning behaviour to enable reflection and feedback. Implement time management and performance measurement applications into the learning process.**

for the provision of personalised advice adapted to emerging situations.

MIRROR supports learning by example: employees can observe the experience of others thus increasing both level and breadth of experience. With the model of computer-supported reflective learning proposed by MIRROR, the learning taking place on an individual,

**Use serious games and simulations, where competent performance cannot be learnt in real situations without great cost or risk.**

social, and organizational level can be integrated and learning results can be transferred to the organizational body of knowledge.

Serious Games for reflective learning are made available by MIRROR to promote creative thinking and to allow trying out alternative behaviours that cannot be

trained safely in real situations. The technological framework called MIRROR Spaces Framework is proposed to manage data exchange between applications.

A key challenge in organisational learning is to bring together informal and formal contexts into a unified learning landscape. Key aspects of this landscape are Personalized Learning Environments and Learning Analytics that use and make sense of data in order to improve teaching and learning. The MATURE project proposes a framework for Knowledge Maturing in the organization. Knowledge Maturing is the process by which knowledge can be transformed from an initial immature idea, via discussing this idea within communities, to the transformation of this idea for wider distribution, piloting, institutionalization, and standardization within the organization. MATURE provide a Knowledge Maturing Model that consist of a series of learning activities aimed to increase the company's capacity to innovate. The model identifies several motivational factors for and

indicators of knowledge maturing. This forms the basis for designing a “family of tools that redefine enterprise systems from a social media perspective, particularly competence management, content management, and process management, and integrate learning opportunities into them” (Schmidt, 2013). A knowledge-maturing scorecard exists, which supports introducing the model into knowledge-intensive organisations.

**Use lightweight tagging of people for more sustainable competence directories.**

Amongst the innovative mechanisms used by MATURE, a lightweight ‘people tagging’ approach stands out that allows for peer recommendations: Employees can associate tags to each other in order to develop collaborative competence

catalogues. Moreover, Learning Analytics are used to identify learning patterns. A task management tool then allows employees to annotate and share learning patterns (annotated with personal experience) and convert them into reusable guidelines. These guidelines can eventually lead to new prescriptive organizational business processes.

**Implement mining of innovative business processes from task management.**

Technology and data-rich learning environments are making it increasingly easier to gather rich data on student activities, but turning data into useful information for learning, assessment, and pedagogical decision-making is still a big challenge for educators. The NEXT-TELL project (Reimann and Mayer, 2013) proposes a set of methods and tool to enable this transition from learning data to knowledge on the



learning process. This includes a design tool that supports the redesigning of teaching and learning activity to make it more evidence-centred in activity and assessment (ECAAD).

**(Re-)design learning activity to be evidence-centric in the collection from activity and in assessment.**

NEXT-TELL offers strategic planning tools (such as SPICE and TISL) for school leaders to use quality data to inform planning and decision-making at school level. The available toolkit provides adaptors to other learning tools and management systems. Teacher inquiry into student

learning (TISL) aggregates and visualises assessment data to render it more accessible to teachers to tune their teaching strategy. SPICE supports linking of performance by indicators with institutional strategy in a balanced scorecard approach.

**Implement strategic planning tools that help monitor key performance indicators for teachers and school leaders from collected evidence.**

NEXT-TELL also provides methods to diagnose the right level of cognitive density for each student and to maintain an individual learning plan. The Learning plan can be created by the students and in collaboration with parents and teachers. This helps preventing cognitive overload in learners, which often leads to student boredom and dropout.

The core components of the NEXT-TELL platform are: a tool for IT tracking and integration including collecting and sharing Open Learner Models, a tool for planning learning activities and formative assessment, and a collaborative sense-making tool to help school leaders, teacher and learners cope with big and rich data. NEXT-TELL provides school leaders with the methods and tools to mature from administrators to strategic leaders, and to enable teachers to be at the centrepiece of innovation, by effectively helping students and peers to explore innovative learning practices.

Olivier et al. (2013) report on roadmapping results in TEL-Map. The project developed an Adaptive Roadmapping method to help stakeholders, which have scattered resources, skills, authority and knowledge, to collaborate and bring together desired futures and innovation processes. Adaptive roadmapping is an innovative methodology to help develop desired socio-technical futures. It allows contextualizing learning innovation to different context scenarios, thereby highlighting critical features of existing desired futures and suggesting change to strategic plans, which may prevent failure and misuse of resources. As example applications of this methodology Olivier et al. (2013) describe the work of two innovation ecosystems mobilised within project's co-innovation groups: one at UK level,

**Create roadmaps to develop desired future vision and strategic plans on how to achieve them in the actual context of the surrounding ecosystem.**

looking at desired future learning scenarios for UK Higher Education; the other at European level, looking at creative classrooms and change in schools. Key results are concept scenarios and roadmaps developed by applying the method Adaptive Roadmapping to these ecosystems.

The TARGET project sets focus on rapid competence development with the help of serious games (Olivera et al., 2013). Instruments are made available to quickly set targets for learning outcomes, devise a learning plan from them, and learn in collaborative role-play with peers and with pedagogical agents. TARGET provides assessment procedures for individual and social reflection, supported by timeline visualisations.

**Use serious games to bring storytelling approaches to learning; use pedagogical agents to complement tutor activity with more rapid feedback.**

With respect to those innovations that are more technological by nature, the following recommendations on uptake can be made.

**Implement facilities for personal learning environments (PLE) and self-regulated learning (e.g. independent study) into existing locally offered virtual learning environments.**

Web 2.0 tools have disrupted the TEL landscape because of the wide scale of adoption and uptake of these technologies. This implied that learners more and more expect to be able to augment and configure

common Web 2.0 tools for personal and self-directed learning. Mikroyannidis & al. (2013) present evidence of success of a self regulated learning approach proposed by the ROLE project. Evidence can be found in the results of the test-beds, showing that the chosen approach for self-regulated learning provided significant improvements in the learning experience in two main ways: by enabling learners to gain more control over the use and manipulation of study materials and by fostering the building and sustaining of learning communities. Personal Learning Environments (PLEs) enable individual informal learners to be part of a shared experience rather than endure lone study.

The main innovation introduced by ROLE is the seamless integration of the PLE composition into existing Learning Management Systems (LMS) in order to allow learners to pursue personal learning on their own, while maintaining the ability to certify learner achievements. This solution reduces costs of changing from an existing LMS to a new system. Personal Learning Environments also widely facilitate the access, remixing and reuse of Open Educational Resources (OER). This creates a positive synergy between Open Educational initiatives and PLEs, which allows learners to access, download, remix, and republish a wide variety of learning materials through open services provided on the cloud.

Laria et al. (2013) suggests that workplace learning needs to move

**Support creativity in the sense of learning on the job, by conscious management using the provided tools (environment and toolkit) and methodologies.**

from formal content-rich courses and commonly used learning management systems to more informal learning approaches, in which learning is embedded directly into the work activities. They present result of the ARISTOTELE project, in which a novel computational work environment was developed to support what they define as “Work-Integrated Intentional Learning”. The ARISTOTELE environment and toolkit enable innovation and open innovation in the enterprise by using information from the collaborative system to manage innovation processes.

The ARISTOTELE environment is composed of a new category of recommender tools, a Human Resource Management (HRM) system, that helps carrying out competence gap analysis and form competence-based teams. The HRM tool considers social relationship and trust networks to define effective collaborative teams and maximize learning and work performances. Moreover a Human Resource Recommender System (HRRS) reacts to goals that are set to the organization by recommending competences to be acquired and alternative learning pathways to foster creativity, innovation, and serendipity within the organization. The ARISTOTELE project developed an innovative Work-Integrated Learning Environment for Organizational Learning, which enables the learning and training processes to be improved by tailoring learning and training to a knowledge worker's needs and expectations and by integrating them in real work processes.

**Support flexible staffing of creative teams using human resource management tools and human resource recommender systems.**

The ITEC project (Johnson, 2013) aims at supporting transfer of innovation within the community of practice of schoolteachers in Europe. ITEC therefore provides a shared model for the classroom of the future: represented as spaces and filled with activity, they are regulated by orchestration mechanisms. The models allow for social



sharing of good practice across Europe: they link tools with the activities they afford in practice, thus supporting teachers in identifying relevant practice of others and in taking up new technological developments with ease. ITEC provides a widget-based infrastructure and a widget store, which also technically makes piloting in large-scale pilots of 1,000+ classrooms across Europe feasible.

**Foster the exchange of good practice across institutional boundaries in the wider community of practice by modelling pedagogical affordances of tools and opening up local virtual and personal learning environments**

On of the main innovation in the

TEL research in the recent years, has been new ways of packaging interactive learning contents first with audio/video podcasts, interactive eBooks, and mobile apps. Wild et al. (2013) report on the forefront work of the Open University, which delivers high quality learning material via its Podcast Website and iTunesU, counting more than 58 million downloads since the start of its podcasting initiative in mid 2008.

**Use eBooks and apps to provide new opportunities for packaging learning for the post-PC world.**

New forms of multimedia and engaging experience can be facilitated by eBooks. EBooks enable us to address issues of memorability, deepening comprehension, avoiding confusion and reducing time to understand the learning content. Moreover the diffusion of mobile learning is enabling TEL to increasingly match lab-based congenial conditions for learning to the real world conditions. Learner demands to learn 'on the move' such as in public transport, on a plane, or in other noisy environments can be addressed effectively and innovatively with mobile and tablets apps. Wild et al. (2013) also report on examples of personalized and enjoyable learning with ebook and mobile apps, pointing out that research is needed into the technological aspects of how to devise and scale up such opportunities for authentic learning and group cooperation.

## Preparing for Europe 2020

The two Networks of Excellence of the European Union in the area of technology-enhanced learning both set out a vision of where future research will take place. Serious Games represent a particularly promising area of innovation, especially because they exploit the appeal to fun to improve motivation, keep learners engaged, and enable testing of complex learning activities, which cannot be easily reproduced in a real world context. The GaLA European Network of Excellence (NoE) on Serious Games is committed to indicate, explore, and shape the use of Serious Games for Technology Enhanced Learning in Europe and beyond. GaLa promotes a variety of tools and initiatives to structure the research activities on Serious Games at international level (Bellotti et al., 2013). The major axes of innovation in the GaLA NoE are: research integration, collaboration, and dissemination of Serious Games initiatives. A European virtual research



centre is a future vision of the GaLA network. The virtual center would reduce fragmentation of stakeholders and improve coordination, integration, and harmonization of the dissemination of knowledge, best practice, and tools for Serious Gaming. GaLA aims at supporting deployment of Serious Games in real educational settings and helps improve knowledge transfer between research and business.

STELLAR, the network with the wider scope of technology-enhanced learning in general, provides a common frame of reference for future research and development: in an intense screening process (see Sutherland et al., 2012), more than 30 proposals were elaborated and evaluated, resulting in a short-list of top-ranking opportunities for research and development. These proposals fall into three areas (Wild et al., 2013): improving awareness of each other and of knowledge, making learning (and teaching) more engaging by monitoring affect and preventing disruption, and - finally - making progress in open collaboration in learning at scale across institutional and cultural boundaries (see Figure 1).

Promising research set out in each of these areas with results to be expected in 2014 and 2015. For the area of awareness, this at the moment particularly involves expected progress in 'Learning Analytics', i.e. the study of data traces left behind in the co- and re-construction of knowledge, their statistical modelling aimed at prediction of competence and performance (rather than their mere description), and innovation in proactive feedback delivery reacting to the predicted likely learning outcome.

Maybe triggered by achievements in the neurosciences and cognitive sciences, there is a lot of research taking place at the moment on

understanding the reward system of the brain to make use of this in learning through more engaging interaction techniques (such as augmented-reality glasses, natural interfaces with gesture control, immersive virtual reality environments). These novel technologies bear huge potential for learning, as they e.g. allow learners to directly experience complex issues, allowing for direct manipulation with natural mapping. At the same time, the deeper question arises how cognition and affect are intertwined and what this means for the organisation of learning. This has implications not only for extreme cases of affective impact on cognition, such as when trying to work with certain spectral forms of autism or dealing with study depression. This has impact on learning as such, as passion profiling with e.g. fit-for-purpose sentiment detection could offer generalizable sensors for detecting and identifying points of intervention in learning processes, both in real life as well as under controlled lab settings.

In the area of open collaboration, several movements of the past have made their recombination into something bigger possible: Open Educational Resources, Personal Learning Environments, Learning Networks, etc. enable the realisation of cross-organisational learning experiences at scale. EBooks and Open Access have started to significantly disrupt the publishing industry, causing also the libraries to rethink their role. The massive open online courses (mooc) model currently forms a focus point of research across the globe and thus future research outcomes in this area can be expected and can be assumed promising.

**Table Introduction.1**

*Innovation matrix: status quo recommendations for each of the three emerging Grand Challenges.*

	Strategy	Methodology	Technology
<b>Awareness</b>	<p>(Re-)design learning activity to be <i>evidence-centric</i> in collection from activity and in assessment.</p> <p>Set up <i>indicator system</i> to link actual performance with strategy.</p>	<p>Implement performance measurement and time management applications into the learning and teaching process.</p> <p>Implement strategic planning tools that help monitor key performance indicators for teachers and school leaders from collected evidence.</p>	<p>Capture data about actual learning behaviour to enable reflection and feedback.</p> <p>Provide teacher dashboards for improved support of orchestration of learning.</p> <p>Pedagogical agents can complement tutor activity with more rapid feedback.</p>
<b>Engagement</b>	<p>Facilitate <i>learning by design</i> and <i>creative learning work</i> to foster serendipity.</p> <p>Use <i>roadmaps</i> as instrument to engage the full ecosystem in TEL strategy development and implementation.</p> <p>Create a culture of resilience to <i>respond more timely</i> to emerging new practices and technologies.</p> <p>Supply <i>engaging technologies</i> such as eBooks, apps, serious games, and simulations.</p>	<p>Build inquiry-based, collaborative learning processes.</p> <p>Creativity means learning on the job, which can be supported by conscious management using work-integrated learning tools and methodologies.</p> <p>Implement mining of innovative work-integrated learning processes from task management.</p>	<p>EBooks and apps provide new opportunities for packaging learning for the post-PC world.</p> <p>Use serious games and simulations, where competent performance cannot be learnt in real situations without great cost or risk.</p> <p>Provide support for ‘emerging learning objects’ (co-)created by the learners themselves.</p> <p>Use engaging storytelling approaches to support learning.</p>
<b>Collaboration</b>	<p>Connect existing virtual learning environments to the cloud.</p> <p>Facilitate <i>creative teamwork</i> to foster collaboration.</p> <p>Knowledge-intensive organisations can support innovation processes by introducing the <i>knowledge-maturing</i> model.</p>	<p>Implement facilities for personal learning environments (PLE) and self-regulated learning (e.g. independent study) into existing locally offered virtual learning environments.</p> <p>Use lightweight tagging of people for more sustainable competence directories.</p> <p>Use the knowledge-maturing scorecard as a change management instrument.</p>	<p>Foster the exchange of good practice and educational resources across institutional boundaries in the wider community of practice by modelling pedagogical affordances of tools and opening up local virtual and personal learning environments (with widget facilities).</p> <p>Flexible staffing of creative teams can be supported with human resource management tools and human resource recommender systems.</p>



*Figure Introduction.1 The Grand Challenges for Research and Development (Wild et al., 2013).*

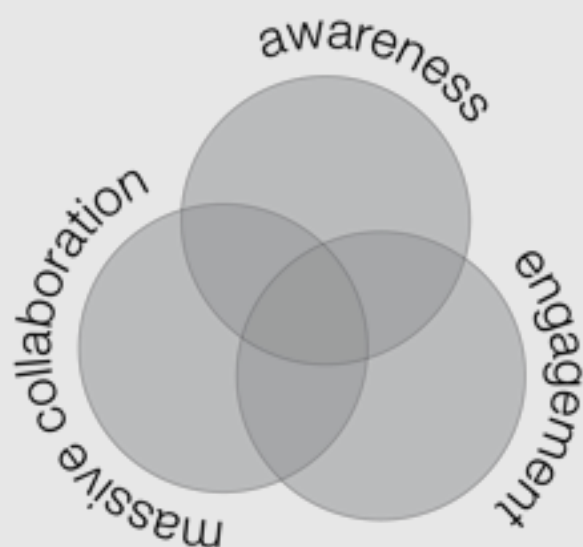


Table 1 on the previous page summarises the key recommendations from research in each of the areas of Grand Challenges, separated into strategic, methodological, and technological recommendations.

On a strategic level, *awareness* support means redesigning existing learning activities in a way that they foster the collection and review of digital learning traces and their (predictive) aggregates. At the same time, this brings along the opportunity to link strategic indicators with these new monitoring and measurements instruments - with care (!) as assessment for learning has different requirements than assessment institutional key performance.

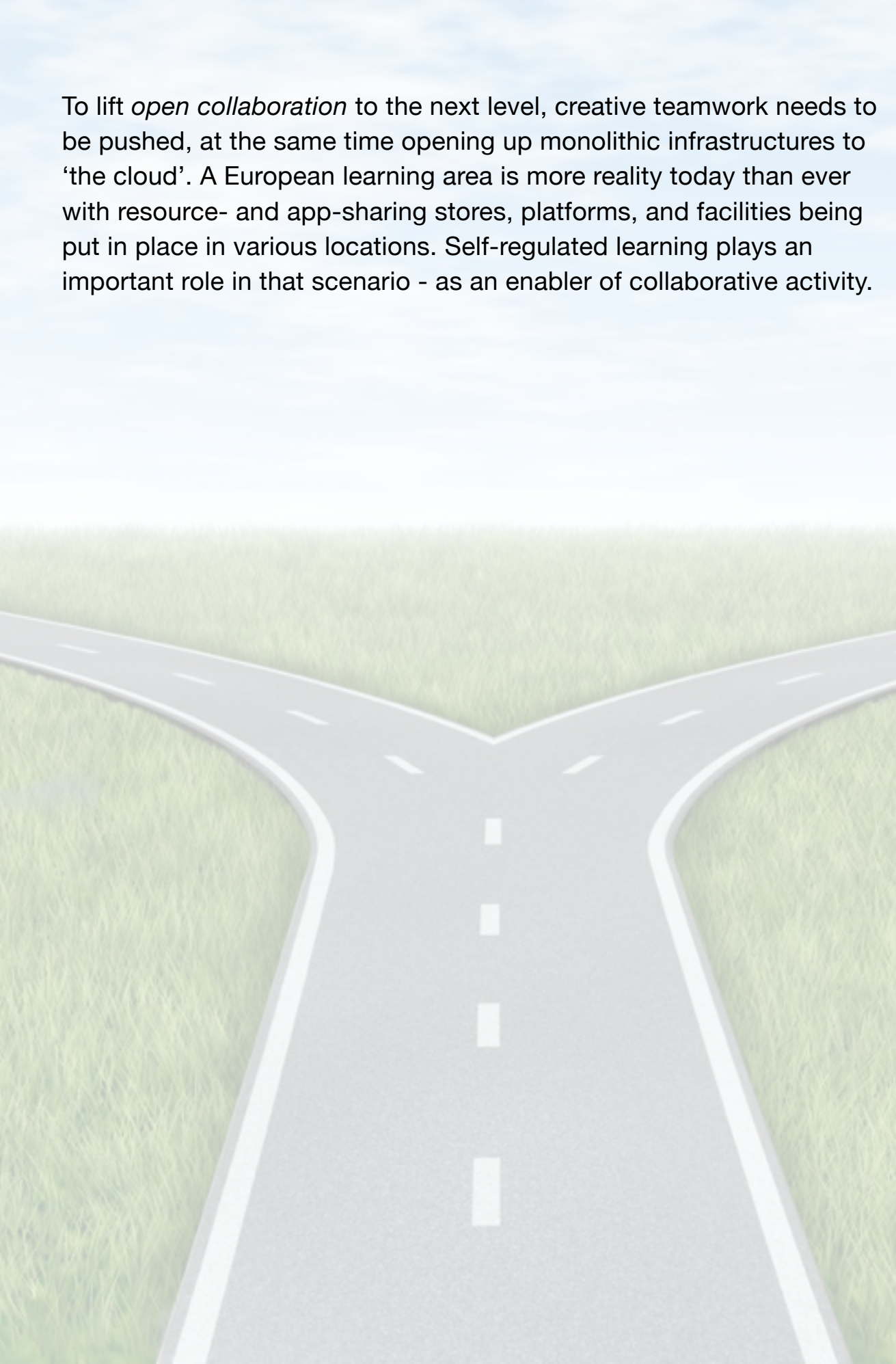
Roadmaps may just be exactly the right vehicle to *engage* the relevant actors not only in this but all other changes relating to technology use in learning: roadmaps can serve as a medium for building shared understanding, developing a joint strategy, and defining the ways forward. To add value to learner-generated content not only releases creative potential, but also fosters engagement - not only in

workplaces, but also in formal education. Both methodology and tools are available for picking up innovative knowledge and practice from actual work and to master tasks more flexibly thus strengthening resilience of knowledge-intensive organisations to changes in demand and requirements (directly from the human resource demands or regulated through curricula). Engaging technologies are available today requiring procurement of adequate hard- and software to bring their use to full potential.

*Table Introduction.2 Actors involved in innovation and in the implementation of innovation.*

Managers & other decision-makers	Consultants & other advisors	Vendors & other intermediaries	Beneficiaries
<ul style="list-style-type: none"> <li>▪ budget holders</li> <li>▪ company directors</li> <li>▪ decision makers</li> <li>▪ educational agencies</li> <li>▪ funders</li> <li>▪ HR managers</li> <li>▪ ministry of education</li> <li>▪ parents</li> <li>▪ team leaders</li> </ul>	<ul style="list-style-type: none"> <li>▪ developers</li> <li>▪ educationalists</li> <li>▪ librarians</li> <li>▪ pedagogues</li> <li>▪ producers</li> <li>▪ researchers</li> <li>▪ technologist</li> <li>▪ marketing directors</li> </ul>	<ul style="list-style-type: none"> <li>▪ book stores</li> <li>▪ content providers</li> <li>▪ government training providers</li> <li>▪ in-house and commercial training provider</li> <li>▪ industry</li> <li>▪ library</li> <li>▪ private education providers</li> <li>▪ product and service companies</li> <li>▪ publishers</li> <li>▪ software providers</li> <li>▪ suppliers</li> <li>▪ universities</li> </ul>	<ul style="list-style-type: none"> <li>▪ customers</li> <li>▪ employees</li> <li>▪ human resources</li> <li>▪ knowledge workers</li> <li>▪ learners</li> <li>▪ learning organizations</li> <li>▪ practitioners</li> <li>▪ schools</li> <li>▪ society</li> <li>▪ teachers</li> <li>▪ tutors</li> </ul>





To lift *open collaboration* to the next level, creative teamwork needs to be pushed, at the same time opening up monolithic infrastructures to ‘the cloud’. A European learning area is more reality today than ever with resource- and app-sharing stores, platforms, and facilities being put in place in various locations. Self-regulated learning plays an important role in that scenario - as an enabler of collaborative activity.

## Innovation is created by ecosystems

The previous sections list the key innovations that are ready for use at scale. Furthermore, they outline the areas of future concerted research activity -- extracted from the screened range of research projects. While knowing about the opportunities at hand or within reach is one thing, introducing and managing innovation and change in an organisation is another: Each of the projects dealt with a wide range of stakeholders involved in the effective development, adoption, and uptake of these innovations in a real world context. From their contributions, we have extracted a list of potentially involved user groups, a selection of which needs to be engaged in development and adoption to render it a success. Identifying those relevant stakeholders can also help identifying clusters of collaboration that can speed up the innovation process.

Within the wider innovator landscape, Olivier et al. (2013) focus on learners as the main innovators, together with those who can help learners through openness: innovators can be teachers, parents, suppliers, and society in general. By borrowing a framework from Future Research studies, Olivier et al. (2013) define the key innovators in the TEL world as:

- *Managers and other decision-makers*: those who have authority to act (such as people from Ministry of education and decision makers) and those who have resources needed to implement plans (such as funders; the directors in supplier companies and budget holders who are responsible for purchases of and investment in technology-enhanced learning in schools, universities, or private education providers),
- *Consultants and other advisors*: those who have expertise in the issue being considered (such as

educationalists, pedagogues, researchers and developers) and those who have information about the topic that no other group has (Marketing directors in TEL product and service companies, people in agencies that support TEL, such as EUN, SchoolNet, or CETIS),

- *Beneficiaries*: Those who have a need that is being addressed (i.e. learners and teachers in schools, universities, commercial and government training providers, both in-house and commercial training providers).

Besides individuals, there is a wide range of organisational units, such as *vendors and other intermediaries*. For example, most of the technologies and methodologies presented in the sections above target a wide range of stakeholders from learners and teachers in the formal educational institutions to employees of companies, and various organisations for continuing professional development (Mikroyannidis et al., 2013).

Other tools focus on workplace learning and therefore target innovators in the organization, enterprise, and business sector such as: HR managers, team leaders and knowledge workers (Laria et al., 2013).

Potential innovators in the eBook movement are publishers, bookstores, libraries (Wild et al., 2013), while main stakeholders of the Serious Game ecosystem can be found to be researchers, developers, industries, educators, game customers, and learners in general.

The full list of 40 different actors identified that are involved in innovation and the implementation of innovation can be found in Table 2, broken down into four categories.

## Moving forward

Table 1 shows awareness, engagement, and collaboration aspects of an Innovation Matrix for each of the three emerging Grand Challenges in TEL. Looking forward, research on those separate challenges is maturing to the point where it is becoming feasible to develop a roadmap on any one of those Grand Challenges and where it is worthwhile to begin to consider combinations of those roadmaps in the context of a particular innovation (e.g., moocs). It is within reach to link the roadmaps of any two of the Grand Challenges and thereby create a set of double-grand-challenge roadmaps (e.g., anticipating the timeline of developments that involve both moocs AND analytics). The next stage is to take any two of those double-grand-challenge road maps and create a three-grand-challenges roadmap. This may be feasible a year from now.

To summarise where we are now, this introduction provides a set of pointers in the form of recommendations on the key strategic, methodological, and technological innovations brought forward by high-impact researchers in major labs in Europe. However, it is premature to develop detailed roadmaps that cover all of that broad body of work: there are too many ‘moving parts’. So we focus for now on individual cases and derive our recommendations from them.

Each of the recommendations elaborated in Section 1 and 2 is detailed in the corresponding chapter of Wild, Lefrere, and Scott (2013). Section 3 adds an actor-centric view: to institutionalise innovation it is recommended to involve the relevant actors in creating a suite of roadmaps to the future, which combine innovations two-at-a-time to highlight early signs of possible interactions between those innovations. This simple action will be helpful in getting researchers to look beyond their area of specialism and to consider possibilities for joint action.

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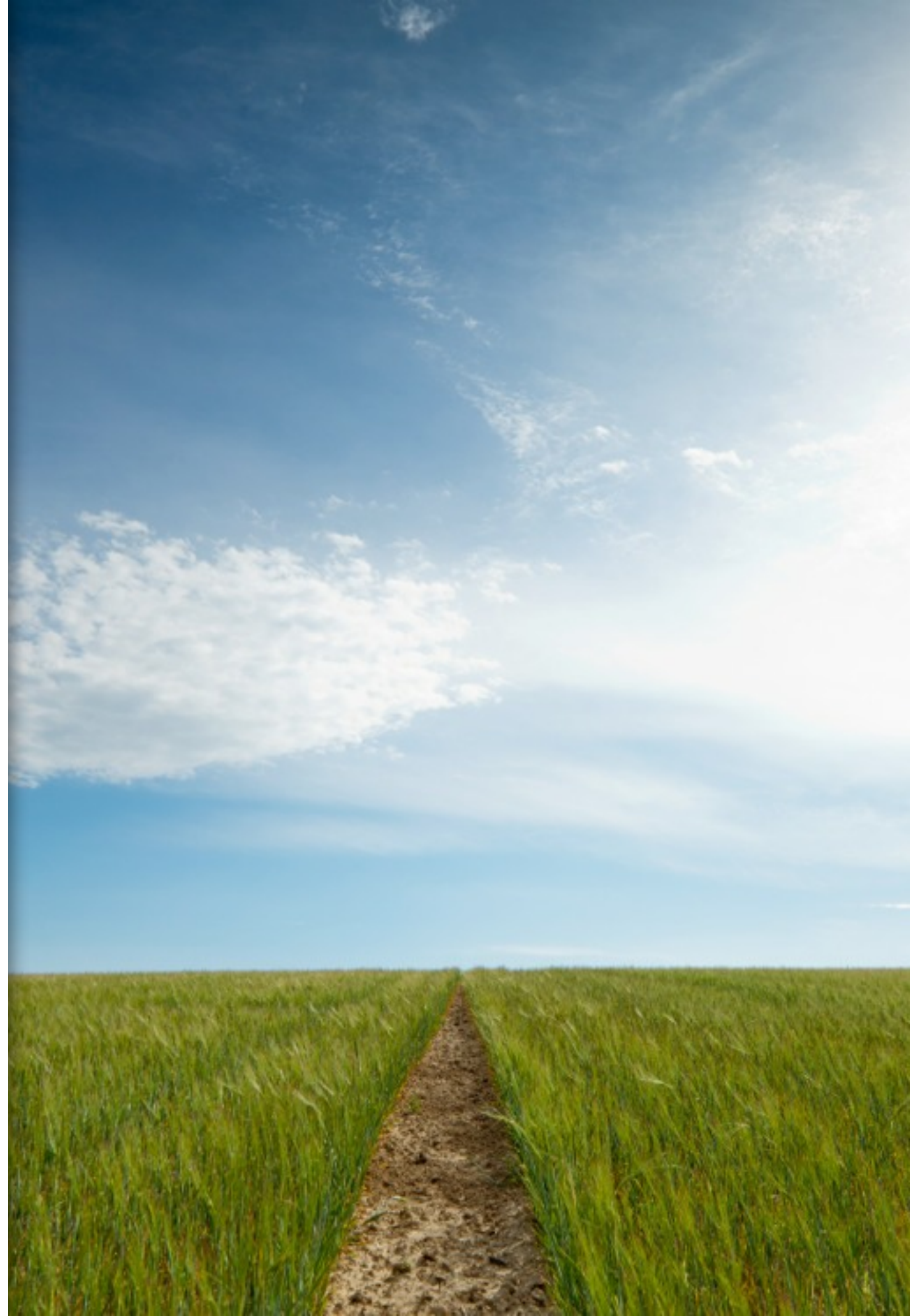
## CHAPTER 1

# The Grand Challenges

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The Open University, UK

Ambjoern Naeve,  
Royal Institute of Technology (KTH), Sweden

This contribution proposes a top-level agenda for research and development in technology-enhanced learning. Within a 3-5 year horizon, one of the key challenges for research is to reduce the barriers to the timely appropriation of skills and knowledge. Learning interactions are designed into complex social networks and is undertaken in a wide range of contexts from self-motivated personal development to externally-driven reactions to economic pressure.



A skills and knowledge focus requires attention by researchers and policy-makers to how to identify areas where updating is judged to be essential; how to awaken and sustain learners' desires to update their knowledge in such areas (e.g., by offering them the prospect of attractive experiences that lead to favourable life outcomes); how to encourage them to develop and apply skills of reflecting upon and refining their updated knowledge, as well as how to make the updating feasible through affordable courses, available anywhere and at any time.

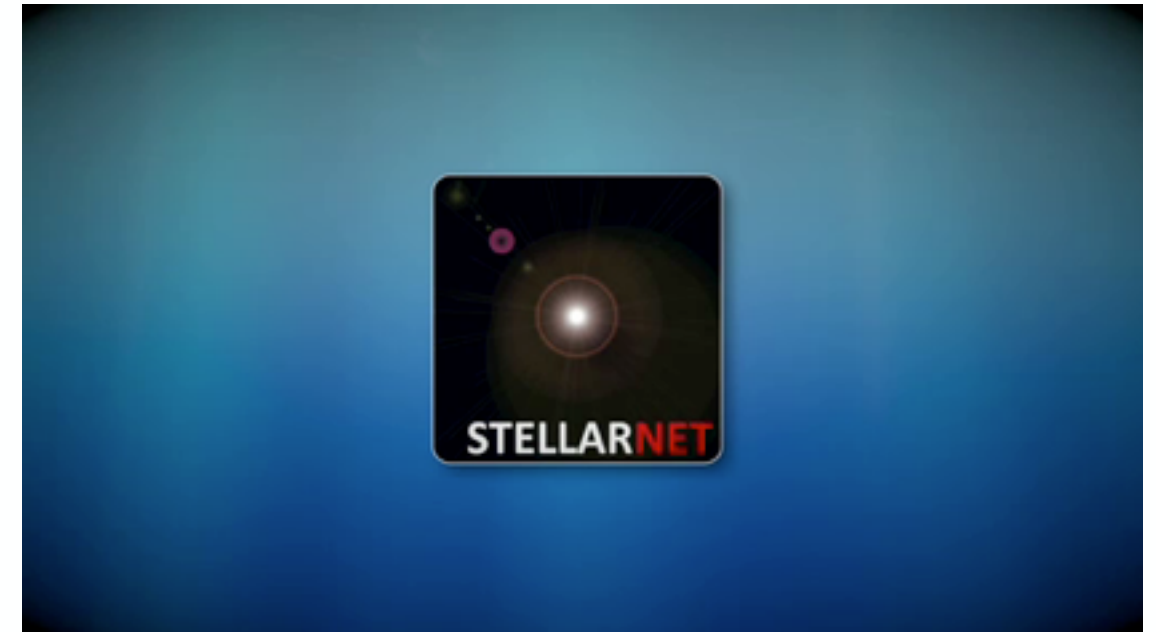
To support all this in terms of delivery, research is needed into the technological aspects of how to devise and offer opportunities for authentic and enjoyable personalised learning and group cooperation (e.g. through scaling up of use of interactive ebooks and mobile learning apps).

Within a 5-10 year horizon, research and development of learning technology and practice should pay particular attention to published outcomes of such projects as Europe's STELLAR and TELMap, especially their public deliverables on identified Grand Challenges for TEL as well as on identified underpinning areas such as analytics, awareness, engagement, and massive collaboration.

Stakeholders in TEL need to understand how to convert research findings into 'industry-strength' recommendations and practices – that will be usable by non-researchers, who are engaged in training, for example, as addressed with the TELL-ME project.

## 1 Introduction

The greater our understanding of the dynamics of research in technology-enhanced learning (TEL) and in related new TEL practices, the more accurate can be our research scenarios. Pretty much everything, however, that defines the field, is constantly in motion: who



*Movie 1.1 Peter Scott, The Open University, UK.*

does what research, with what funding, who gets to know the research outcomes, and what is done with them. Moreover, additional complexity is added via the dynamics of two very different perspectives: 'Within-community dynamics' focus on, e.g., how discussions in the professional networks of TEL researchers can shape their views of what lines of research will be fundable and will become significant for their careers. Secondly, 'external environment dynamics' take account of, e.g., shifts in the timeframe and focus of research funders, from the long term sponsorship of curiosity-driven, blue-sky research to the mid-term or short-term pressure to deliver research results that reduce the time and cost of training people to move into different lines of work.

Arguably, TEL researchers should pay attention to the experience of researchers in cognate fields (e.g., science education, educational psychology) and near-neighbour fields (e.g., computing, engineering, science), especially regarding the effects on research programmes of changes in the balance between short-term priorities and long-term

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needs. Research funding decisions are inevitably affected by economic conditions, but it is easier to defend the funds allocated to research, if researchers take care to communicate the significance of their research findings and engage (directly or via intermediaries) in showing how their research can be applied. This is not always done well in TEL.

The current level of volatility we find in TEL affects both economies of scale and economies of scope. Both weaknesses can be addressed, if researchers collaborate in working towards a shared roadmap to first jointly develop the objectives for and then coordinate R&D, while ensuring independence plus competition and while addressing ambitious but feasible goals that are significant for many people.

Setting coordinating challenges wrapped into desired future (context) scenarios has echoes of the race decades ago to be the first nation to put humans on the moon. That race-to-space was a source of national pride for each nation involved. In the case of the USA, it led to enormous investment by the lead agency (NASA) into “Technology and Knowledge” (cf. the title of this chapter). Concurrently and strategically, other US agencies invested heavily in linked capacity development in the formal education system, including pioneering work on computer-assisted learning (e.g., in STEM: science, technology, engineering and math). Much of today’s TEL can be traced back to those investments and the subsequent and decade-long investments that followed the first Moon landings.

As part of NASA’s programme, attention was given to modelling the flow of new STEM knowledge, including how that new knowledge was codified, reconciled with current knowledge, shared, and applied. This led to knowledge about knowledge, and to insights into ways to improve the various processes used within STEM in the USA. Some of the associated analytic knowledge is the domain of Scientometrics (aka the science of science, see [1]). That field studies the ways in which new knowledge and practices diffuse and are received within scientific communities. It seems that there are well-defined patterns in

the evolution of the aggregated knowledge base of the natural sciences: what are taken to be the facts and givens in particular branches of science, the technologies and practices within those branches, their corresponding theories, etc. For example, each year a proportion of the consensual knowledge in a field is reviewed, challenged and updated or replaced by members of that community, through such processes as discovery, dialogue, and discussion. The proportion appears to vary with the field, but is predictable within a field.

In this chapter, we assume that technology-enhanced learning, TEL, is sufficiently science-like for similar gross patterns to be modelled in how it evolves. Within the scientometrics literature, there is insufficient data for us to draw parallels between the knowledge dynamics of particular fields of science and specific areas of TEL. It is still an open question whether such evolutionary patterns are likely within TEL as a whole and – once identified – whether they would affect future research scenarios. If so, it would be very useful in determining, how they can be utilised to predict how TEL research and innovatory practices will be appropriated by users, how the focus of TEL research changes. This would help to address Grand Challenges, and show us how to enable TEL stakeholders to better prepare to anticipate change and scale up impact early of innovative break-throughs.

Within this contribution, we will make two predictions about where TEL innovation can be expected. The first deals with the near future. Looking at institutions that spearhead innovation in the field, a rather ‘safe’ prediction is made – what we can expect to see on a grander scale within the next 3-5 years.

The second prediction deals with the more distant future. Building on the expertise of several hundred specialists and stakeholders brought together in the STELLAR network of excellence [12] and the TELmap coordination and support action [8], three areas of innovation are elaborated, which pose particularly rewarding opportunities for



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## Core research areas

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Computer-supported collaborative learning  
Connection between formal and informal learning  
Contextualized learning  
Emotional and motivational aspects  
Improving practices of formal education  
Informal learning  
Interoperability  
Personalisation of learning  
Reducing the digital divide  
Ubiquitous and mobile technology and learning  
Workplace learning

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*Table 1.1 Core research areas of TEL*

research and development on a 5-10 year horizon. We will present corroborating evidence for these three overarching themes where available.

As with any forecast of a more distant future, this vision is rendered real only when the community and its stakeholders work towards its achievement. This work is informed by a large-scale Delphi study [15], eight dedicated workshops [7], and countless consultation meetings [16] helping to extract where the TEL professional community and its stakeholders see need and identify potential for further research and development.

This ground work assures us that it is therefore not so much a question of whether these distant predictions will continue to be in focus of future efforts. It is rather a question of what quality expected achievements will have. Only the future will show.

## 2 The near future

Technology-enhanced learning is the study of building knowledge and competence of humans, assisted by machines, the software they run, and – not least – the purposive practice required in order to excel. The field can be broken down into the sub areas listed in [Table 1.1](#).

Each of these research areas has fostered innovation in technology and practice over the years. The recent computing industry trend is towards the ‘app-ification’ of products - creating small, low cost, limited function applications - so small indeed that they are called ‘apps’. This drive to the small price and small function app coupled with more affordable, and more powerful portable devices into the end-user consumer market, has made new formats for packaging interactive learning content very popular. First audio, then video podcasts, apps, and – more recently – interactive eBooks and course packages are offered by virtually all universities spearheading innovation in learning technology as of today. This has become a major driving force in our learning world. In February 2013, Apple announced over a billion downloads of free educational content in iTunes U. At that time, the

UK's Open University (OU), for example, logged over 60 million downloads via the Open University on iTunes U since its entry into that channel in mid 2008. The OU currently offers more than 400 eBooks for download with more than 5,000 hours of study. Additionally the OU currently provides more than 50 free open online courses via iTunes U and more than 600 via its web platform OpenLearn.

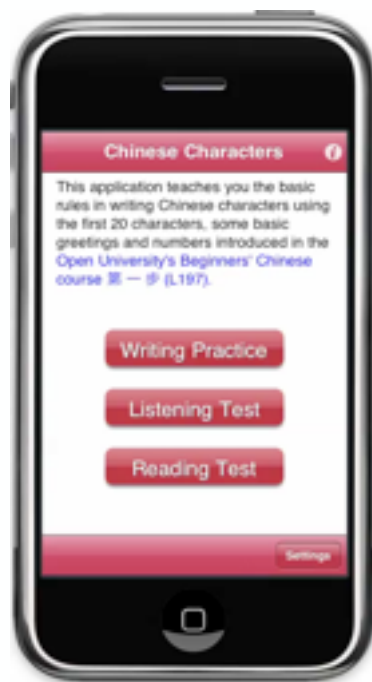
Movie 1.2 provides an example of such a learning app: 'Chinese Characters' allow learners to train stroke order and direction in the writing of symbols. Being linked to the 'Beginning Chinese' course offered by the OU, the app adds reading and listening tests. TEL research is growing in sophistication, so that it is increasingly possible to match lab-based testing of learning apps to real-world (post-

training) demands on users; examples include helping users to maintain accuracy of stroke direction whilst holding a device on public transport; or to listen accurately against a noisy background.

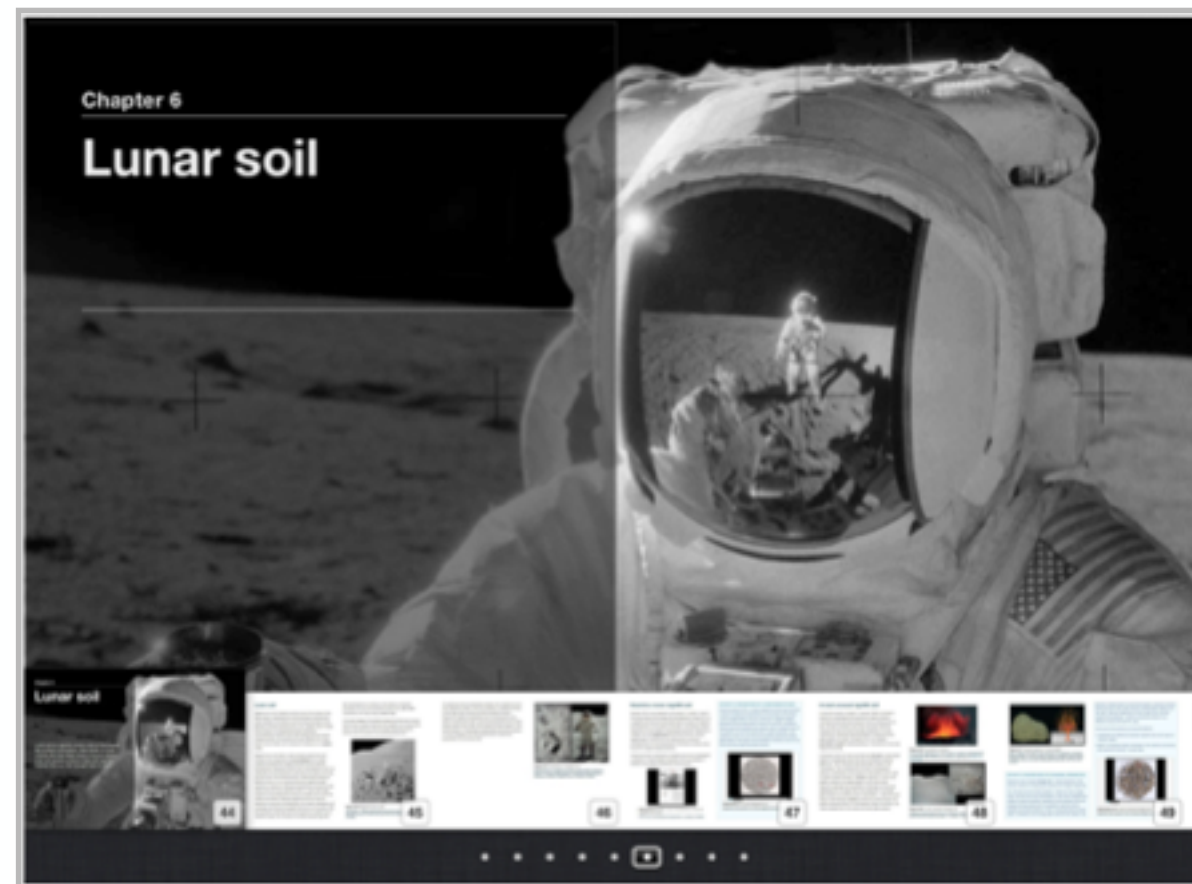
Figure 1.1 demonstrates the capabilities of modern eBook readers. Enhanced layout facilities such as implemented in the latest authoring formats create an appealing reading experience. These new ebook formats allow for the embedding of audio and video material,

*Movie 1.2 Example app:  
Chinese Characters*

This OU app lets learners practice the drawing of Chinese characters; it also helps to test reading and listening skills.



*Figure 1.1 Example eBook: Moon Rocks*



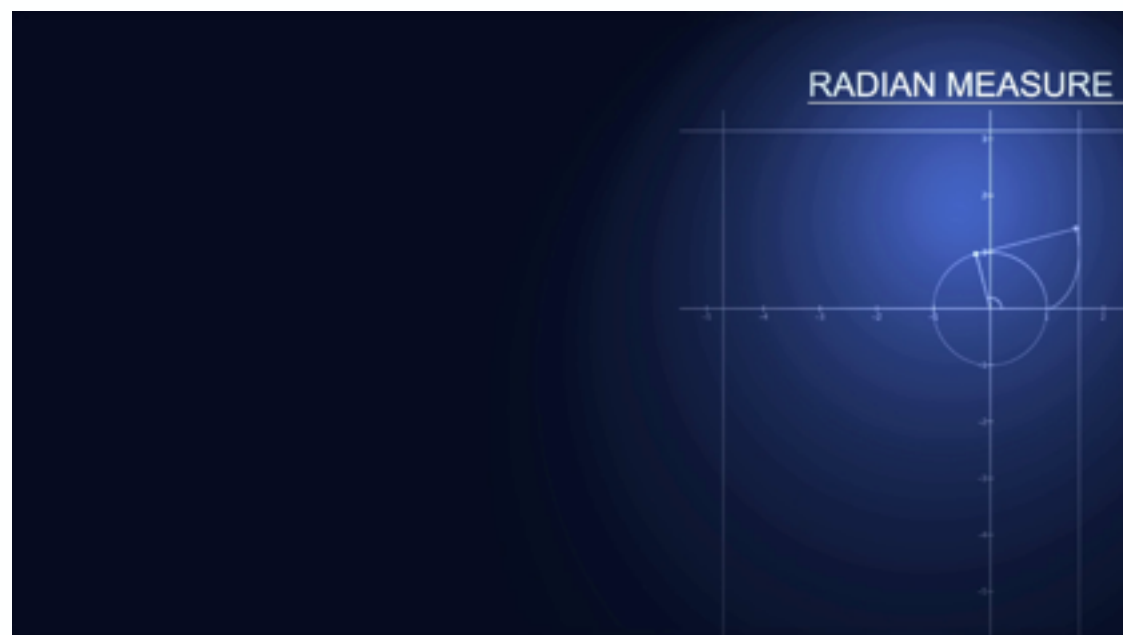
simulations, interactive exercises, and all other sorts of gadgets. The eBook is more and more compatible with the abilities of a regular web browser. Again, TEL research can move out of the lab (congenial conditions for e-reading) and into the post-training world of the learner.

Reading a well-made eBook can become a very engaging and satisfying experience that goes well beyond what we have been used to with books. This is starting to extend to all common book reader platforms, causing a seismic shift in publishing, affecting everyone from the publisher, to book store, to library.

It is said that 'a picture is worth a thousand words'. TEL makes it possible to provide learners with pictures that can be personalised and animated dynamically (in real-time), to take into account the context of the picture, i.e., the semantics of the accompanying text in the eBook;

### Movie 1.3 Example of mathematical animation

Example of a mathematical animation video, used to teach a threshold concept in mathematics: radians.



to reflect each learner's current state of knowledge; to enhance the memorability of the picture; to deepen understanding of the concept or point being communicated by the picture; to reduce the time taken to gain that understanding; and to reduce the risk of confusion with other concepts. [Movie 1.3](#) shows an example of such animation to teach a threshold concept in mathematics: radians. It addresses key issues (memorability, deepening understanding, reducing time-to-understanding; avoiding confusion). This video can be embedded in an adaptive learning path, for example, interjected when a misconception of the threshold concept of a radian is detected. Furthermore, with the current state of the art in TEL, it is already possible to personalise such animation in a cost

effective way, thus paving the way for in depth personalisation of content.

TEL research on eBooks is gradually expanding to include long-standing issues such as how to use non-text media to enhance text. The semantic web offers a possible over-arching framework, a structured information architecture called a Knowledge Manifold, from which the following 3-phase research scenario emerges (see [Table 1.2](#)).

According to [10], TEL policy should assume the progression of TEL research through those phases, and should also explore the economies of scope and scale that could emerge from supporting work on the potential synergies between each phase of research.

Implicit in those phases is the need to check the assumptions of TEL researchers, such as, for example, the following provocative pedagogical assertions:

*Table 1.2 Derived 3-phase research scenario.*

PHASE 1 'Semantic Isolation'	PHASE 2 'Semantic Coexistence'	PHASE 3 'Semantic Collaboration'
- XML (or other 'semantically free' formats)	- RDF(S)	- Ontology management systems
- Document-based descriptions	- Graph-based descriptions	- Ontology mappings
- Closed description spaces	- Open description spaces	- Contextualization
- Fixed metadata set (tags and values)	- Freely evolving metadata (tags and values)	- Controlled evolution of metadata
- Databases with entry-portals	- Databases with p2p connections	- Joint searching (inter-search) with dynamic queries
- No joint searching (inter-search)	- Joint searching (inter-search) with static queries	
	- Retrieval	



- Nobody can teach anything. A good teacher can inspire to learn.
- Motivation to learn is based on the experience of subject excitement and faith in learning capacity from live teachers.
- Learning quality is enhanced by taking control of one's own learning process.
- No 'problematic' questions can be answered in an automated way. In fact, it is precisely when questions break the pre-programmed structure that the deeper part of the learning process begins.

### 3 The (more) distant future

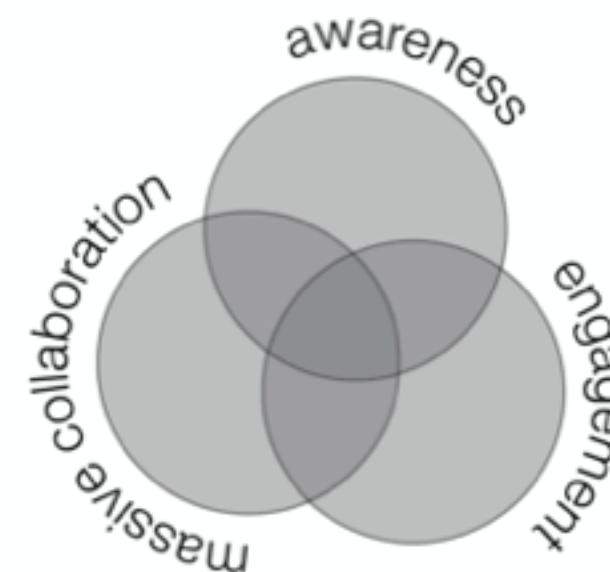
All of the core research areas listed in Table 1.1 above can name a number of open problems for which further research and development is deemed necessary. The open network of excellence STELLAR has investigated this in depth in a series of consultation events and according reports. In total 32 bounded research opportunities (so called Grand Challenge Problems) were identified, which originated from two main sources.

Using a slightly modified Delphi approach that surveyed researchers as well as stakeholders of technology-enhanced learning (such as educators, businesses, or policy-makers), 10 Grand Challenges were aggregated, investigated, and documented. More than 500 experts worldwide participated in the panels of the study [15].

Another 22 bounded research opportunities were drafted from eight dedicated workshops organised into an Alpine Rendezvous in 2011 and refined in several iterations on- and off-line [7].

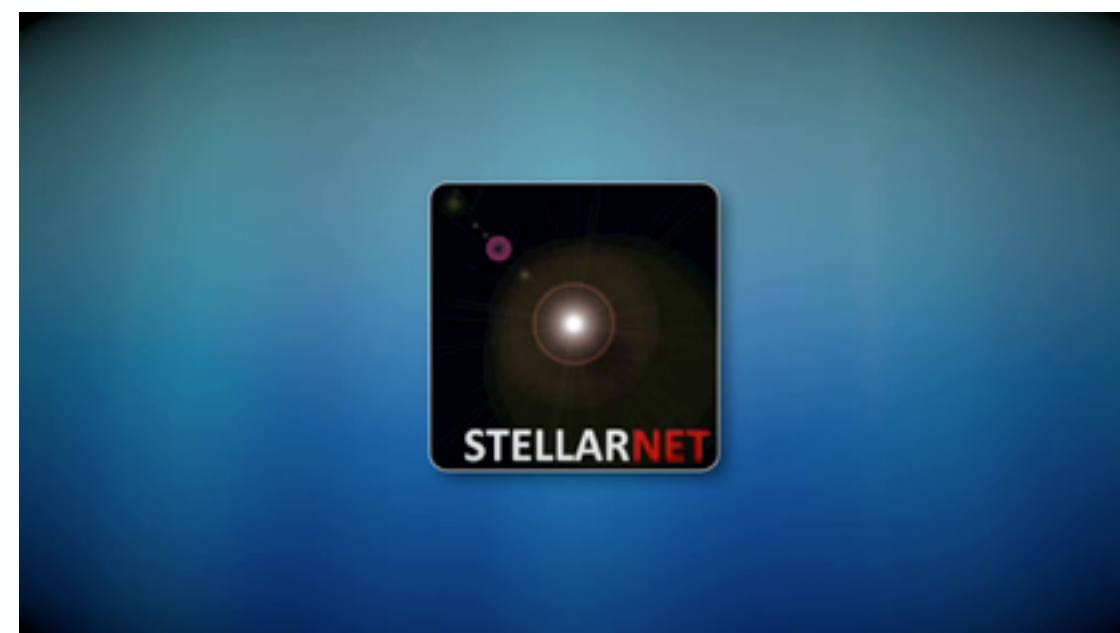
Following a qualitative evaluation workshop and a quantitative rating exercise, the top ten opportunities were short listed and released to

*Figure 1.2 Three main strands of innovation*



the public in [16]. The rating criteria were the potentials for social, educational, economical, and technological impact as well as feasibility, measurability, scalability, and clarity/attractiveness. Together

*Movie 1.4 Dr. Denis Gillet, EPFL, Switzerland*



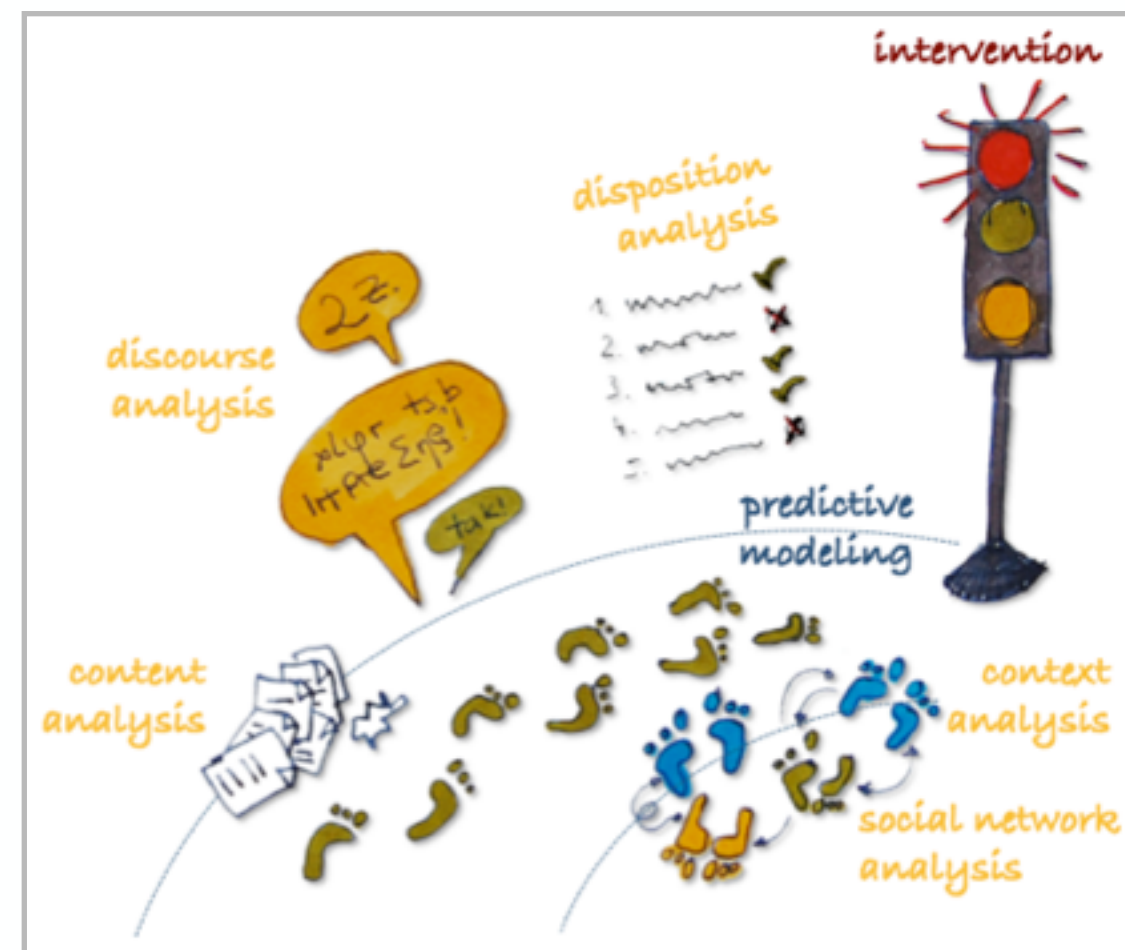
they represent not only what's feasible and desired, but also what affect the lives of a larger number of people, businesses, and systems. Within this contribution, we analyse the ten top-rated challenges further and identify three common underlying strands of TEL research they require.

The shared three strands are: 'awareness', 'engagement', and 'massive collaboration' (see [Figure 1.2](#)). Thereby, awareness deals with observing traces of learning, predicting performance, and intervening where required. Engagement denotes the study of cognitive affect and motivation, helping build and sustain passion in learning. Massive collaboration accommodates an area of future research in which the new capabilities we have gained through advances in infrastructure meet open practices spanning across big crowds of learners and teachers in both formal and informal learning and across the various stages of lifelong learning.

## 4 The future scenarios

Fostering awareness with the help of learning analytics relates to the study of digital traces left behind when (co-) constructing knowledge and developing competence using predictive models that allow for advising on performance improvement of individuals.

Five areas can be postulated for incorporation in the analysis-related parts of future research scenarios: social network, content, discourse, disposition, and context analysis [3], see [Figure 1.3](#). Some of the areas represent widely-anticipated, incremental additions to today's scenarios, and others are more contentious. To illustrate: there is consensus that more research is highly likely on the analysis of content interaction and production, because research in this area has made substantial progress in recent years, often based on weblog analysis (e.g., [21]) and text mining (e.g., [19]). By contrast, the other areas do not seem such obvious candidates for major research directions in a TEL context. Social network analysis denotes the study of the nature



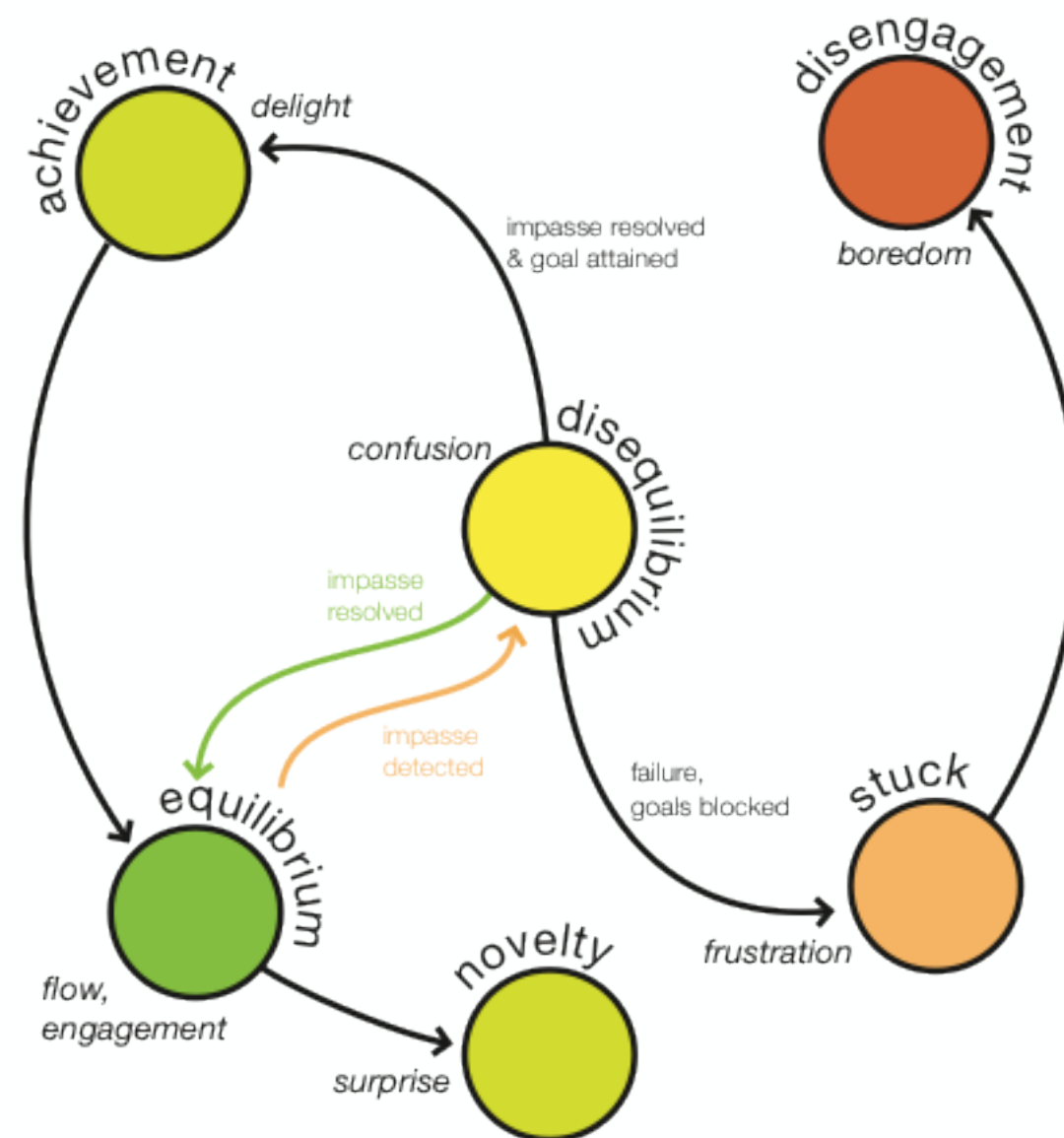
*Figure 1.3 Different types of learning analytics*

of interpersonal relationships and investigating as well as predicting their structural value. Discourse analysis is about investigating learning conversations (and its substitutes). Disposition analysis relates to studying potentials for action, particularly those of learning literacy. Context analysis lays focus on the ecosystem, i.e. spaces, situations, activities, in which learning takes place, taking account of differences in configuration (such as for mobile, informal, formal, or group use). In our view, it will become much easier and cheaper over the next five years to undertake substantive TEL-related research in those areas, and awareness of this change of circumstances will spread, so that more researchers enter this area.

Recommendations, guidance systems, automated feedback, and other forms of formative assessment will particularly benefit from these new possibilities.

The study of motivation and engagement has brought up fundamentally new models of how cognition and affect mutually influence each other. For example, [6] postulates a cognitive-affective state model of learning, parts of which were already validated in experiments with AutoTutor, see Figure 1.4. Disengagement is a consequence of unresolved ‘impasse’, i.e. a cognitive conflict, a contradictory experience, etc. An impasse moves learners out of a state of equilibrium (flow) into a state of disequilibrium (confusion). Achievement not only gives delight, but moves learners back into flow, whereas unresolved conflicts can move learners into a state of frustration, feeling stuck, and ultimately into disengagement (boredom).

Many proposals for sensing cognitive-affective states of learners have been made and are currently trialled in user tests: wristbands measure galvanic skin resistance as a proxy of affective states, finger clips are used to measure blood volume pulse frequency as indicators of arousal and stress, to name but a few experimental ones [17]. Text mining techniques are applied for sentiment detection (see, e.g., [11]). All of the above are now becoming feasible for mass adoption as research areas, and there will be much lower barriers to entry in those research areas. Other already widely successful proposals for new research areas include explicit stating of affective states, such as popularised by commercial applications: Facebook’s ‘like’ and Google’s ‘+1’ are well known examples. To utilise the dependency between cognition and affect, this will have to be implemented into learning environments, which could raise barriers to research here. For example, by extending existing social learning platforms with community engagement features such as recommender systems and engagement indicators.



*Figure 1.4 An example cognitive-affect model (redrawn from D'Mello & Graesser, 2012)*

Novel techniques offer new ways of engaging in learning: haptic and gesture interaction, for example, offer potential in natural mapping. Augmented reality applications, simulations, and serious games offer new forms of interaction that promise an exciting future, helping learners (and teachers) in building up and sustaining engagement with more ease than in the past.



Engagement in learning will be easier to support in the future, not least with the help of improved learning models and support technologies that care for both cognitive as well as affective states of learners. Novel and more engaging interaction techniques will not only seamlessly bridge between the virtual and the real environments, but also provide a more natural experience of digitally enhanced learning.

Massive collaboration is the logical consequence of advances made both in technical infrastructure and pedagogical practice. This can be broken down in the following areas of research (see [Figure 1.5](#)): personal learning environments (PLE), open educational resources (OER), open educational practices (OEP), personal learning networks (PLN), massive open online courses (MOOC), see [Figure 1.5](#). In terms of Open Educational Resources, the OER evidence hub [5] currently lists more than 300 projects and organisations world wide with more than 100 research claims, more than 100 issues, and more than 100 proposed solutions. How to promote engagement with OER amongst academics is well understood, see [20]. Personal learning environments have matured both with regards to technology [13] as well as pedagogy [2]: it is possible today to assemble a personal learning environment from distributed tools, following psycho-pedagogical guidelines. Pedagogical patterns are collected and shared on a wider, cross-organisational scale [9] as open educational practices.

Personal learning networks can be formed with ease today through social media and social software [18]. Large-scale teacher networks have been formed [14].

The first example of such massive collaboration can be found in massive open online courses [4]. Such courses typically encompass thousands to millions of people across the globe, including learners inside as well as outside of the institution offering the course.

This explosive mix bears the potential to rethink formal as well as informal education, possibly leading to a more open educational

*Figure 1.5 Massive collaboration in learning*



system in which collaboration across boundaries is rather the norm than the exemption.

## 5 Conclusion

Apps and eBooks have become widely affordable and accessible, and have started to disrupt the traditional value chain in education and professional development. Improved awareness, improved support in building and sustaining engagement, and seamless collaboration at scale and across boundaries can be expected to further change the future of technology-enhanced learning.

Many things will change, but the essence of learning will not. We will still have learners in the future and we will continue to learn through communication. Alas the means with which we do this and – in effect – learning conversations of the future will be signified by more transparency, will stress their social component, and will be

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hopefully more passionate. Educational institutions and systems will be less incarcerated in their physical boundaries. The future of learning will be a little bit more open and learning more personalised.

This does not mean, however, that learning will be less formal, and research scenarios will change to reflect this. The models of what's formal will change and maybe research will shift to assess key factors in the shift from transforming today's informal learning and making it an essential part of tomorrow's formal learning.

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# Learning by Design

One way of engaging students in science-based learning uses contextual collaborative assignments in which students create solutions for socio-technical problems together with other students. The Science Created by You (SCY) project delivers learning environments ('missions') that offer students these opportunities. This chapter describes how SCY missions are designed to accomplish this and sketches the obstacles that need to be overcome to upscale 'SCY-like' learning experiences.



Contemporary education faces the challenge of providing students with stimulating and relevant learning experiences. In this chapter we outline a pedagogical approach that answers this challenge by focusing on inquiry activities and collaborative practices in the context of solving real world, societally relevant problems. Students are offered problems that have a real world footing, for which they need to discover a viable and possibly novel solution, to think from multiple angles, and to perform investigations and collaborate with peers who may sometimes bring different forms of expertise to the task. An example of a socio-technical problem is the design of a sound barrier wall, in which not only the physics of constructing the wall but also environmental circumstances and the opinions of civilians living near the proposed wall need to be considered. Students find they must design a solution for a societal, technical problem, and in this sense they act as ‘engineers’. This instructional approach, which we call *learning by design*, incorporates inquiry and collaborative approaches. As some studies show, it may help students to acquire deep conceptual insights [1] and is also beneficial for students’ engagement [2]. Unlike the situation for inquiry and collaboration per se, there is little software that specifically enables learning by design. The SCY learning environment (SCY-Lab and the SCY missions) was specifically designed to enable students to learn in a design-based way.

## 2 SCY innovations

The Science Created by You (SCY) approach concentrates on learning in science and technology domains, and uses a pedagogical approach that centres around products called ‘emerging learning objects’ (ELOs) that are designed by students. Students work individually and collaboratively in SCY-Lab (the general SCY learning environment) on ‘missions’ that are guided by socio-scientific problems [3; 4]. Completing SCY missions requires a combination of knowledge from different content areas (e.g., physics, mathematics, and biology, as

*Movie 2.1 Prof. Dr. Ton de Jong,  
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well as social sciences). Along their way to a solution for the problem that characterises a mission, students produce many types of ELOs. Examples of types of ELOs include: executable models, concept maps, data sets, hypotheses, tables, summaries, reports, and experimental procedures. SCY learning environments centre the entire learning process around creating, sharing, discussing, and re-using ELOs.

SCY-Lab is the general SCY learning environment. SCY-Lab provides students with dedicated tools for creating ELOs. Examples of tools include a modelling tool, a concept mapper, an experiment design tool, simulations to generate data, and tools for analysing data tables. Tools can be adapted to the student or the context by supplying scaffolds, adaptations to the tools that inform or support students. Tools are supplemented with services that help students in their work. Services include a) an awareness service that gives an overview of the presence and activities of peer students, b) a portfolio service in which students can save their ELOs so that they can be examined by the teacher, c) a

navigation service that shows students a graphical overview of the learning environment, and d) a repository service in which students can search for ELOs (already created by themselves or others). The configuration of SCY-Lab is adaptive to the actual learning situation and may provide advice to students on appropriate learning activities, resources, tools and scaffolds, or peer students who can support the learning process.

A SCY mission is SCY-Lab provided with domain content. To date, four SCY missions have been developed, each of which addresses specific science content in the context of creating a particular final product. Students in the CO2-friendly house mission are assigned the task of designing a CO2-friendly house. In the Healthy Pizza mission the final product that must be designed is a healthy pizza (either in the form of a real pizza or using a simulation). The ECO mission is intended for learning about topics at the junction of biology and ecology. Students' final products are a concept map about relations in an ecosystem and a video report that illustrates the inquiry processes that they have applied. In the forensic mission students are engaged in an investigation to find a criminal offender. They must identify the techniques they will use to analyse DNA or ink samples, elaborate or justify their experimental procedure, carry out real experiments, and analyse their results.

The SCY project is unique in the sense that it brings together all types of facilities that guide the students in the difficult process of learning to approach problems like an engineer. First, there is the problem that they need to solve, which must be recognisable and close to the students' reality. An example is the design of a healthy pizza. We aimed this mission for students at the age of around 12-14, who can easily recognise this issue as an important one. Table 2.1 displays the general assignment students receive; this assignment explains to the students what they need to design as a final product and introduces the knowledge that can be acquired in the mission. It is characteristic of SCY missions that students *acquire knowledge in context* and learn

Table 2.1 General assignment: Pizza Mission.

The challenge: A Healthy Pizza

Pizzas are among the most popular dishes in the world. Many people eat pizza regularly. Maybe they even serve pizza at your school canteen. But pizzas usually contain high amounts of calories, fats and salt. And that may not be very healthy at all. Children (and many adults) in Europe and the U.S. consume more sugar, salt and fat than thirty years ago. These dietary habits have led to an increase of health problems such as obesity, diabetes, high blood pressure, and heart-related diseases.

But pizzas do not have to be unhealthy. During this mission, your job is to create a healthy pizza for your school canteen. Taking into consideration the nutritional value of the different ingredients, you must come up with a pizza that is both healthy (e.g., contains less fat) and tasty.

In the following lessons, you will learn about the nutrients in our food, you will familiarize yourself with the classification of food products according to the food pyramid, and you will learn how to interpret labels on packages of food items. You will also learn how the digestive system works, and what the major diet-related health problems are. Finally, you will use your new knowledge to create your optimal healthy pizza.

Have fun!



about a diverse set of domains. In the pizza mission, students learn about: nutritional value of food items in general (carbohydrates, fat, proteins, energy, vitamins, etc.) and of various pizza ingredients in particular; the classification of food products (grains, fruits, vegetables, milk, meat, and beans); information on energy (calories) and the human digestive system; and general math knowledge such as working with percentages. In addition, students learn about scientific processes. For example, they learn how to create hypotheses or to monitor data that come out of an experiment.

Second, a design process like this would be too difficult for students to perform without *guidance and scaffolds*. Therefore, all SCY missions offer students a way to find a viable solution through a specific scenario [for a description of SCY scenarios [see 3](#)]. A scenario consists of several phases that centre around a specific learning process. Each phase has a specific ‘space’ in the SCY mission. For example, there is a space for gathering information (students watch a video and read a (scientific) article about unhealthy eating habits or how tomato sauce can help prevent cancer). In another space students record their eating and exercise habits for a single day and register a so-called health passport. In a ‘conceptualisation’ space students create a table with the most important nutrient categories, calculate the amount of energy in several food products, and complete a pizza ingredients table to indicate the nutritional value information of pizza ingredients. In yet another phase, students design a pizza, using a pizza simulation specifically developed for this mission. In all of the phases students receive tools and scaffolds (such as the pizza simulation) specifically intended for creating products in that phase. Figure 2.1 presents all the phases (called Learning Activity Spaces, or LASs) in the Pizza mission, along with the products that are created in each phase.

A third key innovation in SCY is that students can save their products, tag them and find them through a dedicated search mechanism. This implies that students can exchange products (e.g., simulation

outcomes, concept maps, health passport, etc.) with other students for discussion and also can use a product from another student as a starting point for their own learning. SCY missions also allow students to share products in real time at a distance and to work on an object collaboratively. To accomplish that, the students have a chat (attached to an ELO) as a way of communication.

A fourth innovation in SCY is that SCY-Lab is designed with ELOs as the central entities, with all functions centred around the ELO(s). ELOs can be taken from one phase to another, saved in a database for later retrieval, submitted to a portfolio and be shared on-line with other students. The centrality of ELOs is further emphasised by having all ‘facilities’ needed to create the ELO be designed as drawers extending from the ELO window. The chat, for example, is an extendable window to the right; an assignment to create the ELO, background information, a tagging facility, and a facility to ask for peer comments are located in separate extendable drawers to the left. In Figure 2.2, students create an ELO that is called the ‘health passport’. The screenshot shows the

Figure 2.1 Sample interface for the Pizza mission.

The screenshot displays the SCY Lab interface for the Pizza mission. The main window is titled 'My Health Passport' and contains a form for creating a health passport. The form is divided into several sections:

- Assignment:** A text box on the left providing instructions for the health passport.
- Health passport:** A central form with fields for:
  - Name: jacob
  - Birth Date: 01/03/1998
  - Weight (kg): 70
  - Height (cm): 185
  - Gender: ☒ Boy ☐ Girl
  - BMI (Body mass index): 20.45
  - Heart rate (bpm):
  - BMR (kcal/day) (Basal metabolic rate):
- Calorie intake:** A field for 'Daily calorie intake'.
- Estimated energy requirements:** A field for 'Estimated energy requirements'.
- Calorie balance:** A field for 'Calorie balance'.
- Evaluation of diet:** A section for 'Evaluation of diet (compared to the food pyramid)'.
- Conclusions and recommendations:** A section for 'Conclusions and recommendations (taking into account the calorie balance)'.

On the right side of the interface, there is a chat window with a list of messages and a 'Send' button at the bottom.

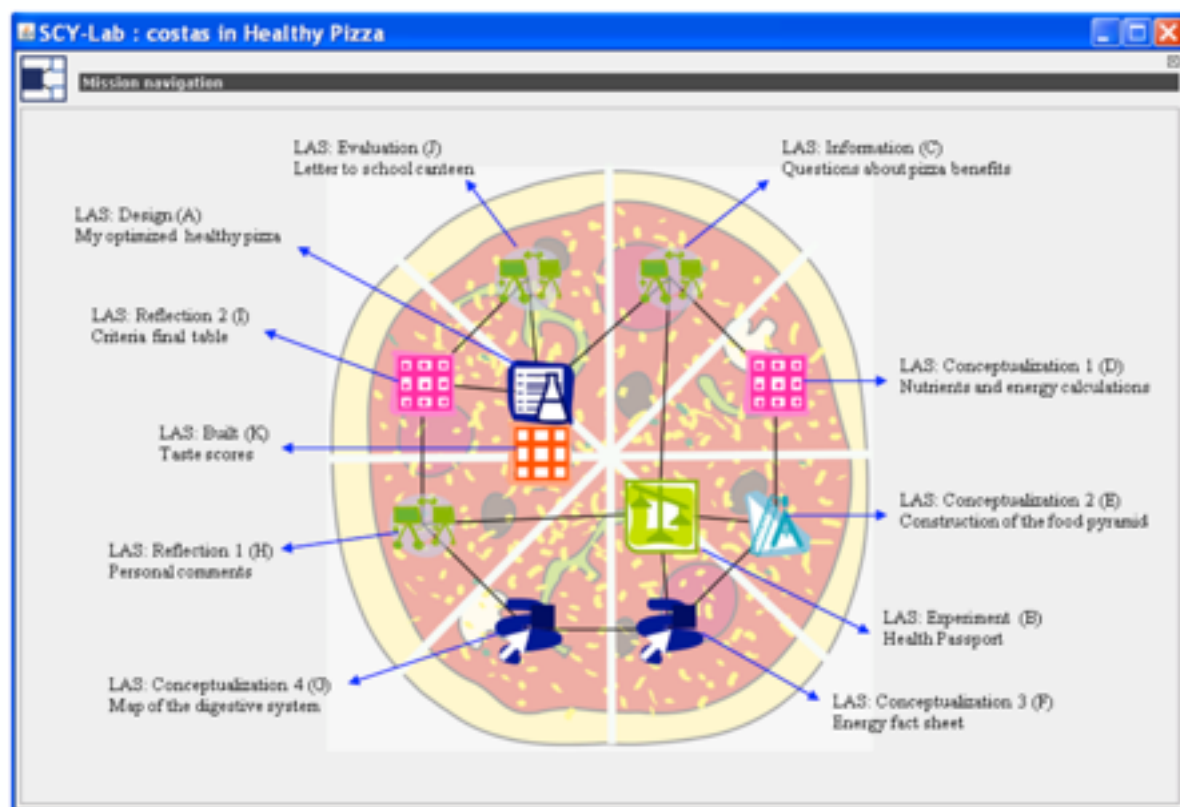


Figure 2.2 The 'mission map'.

Showing all phases and associated products for the Pizza Mission.

extendable drawers (which here do not include the background information, which was not offered for this particular ELO).

### 3 SCY on a world-wide scale

Imagine a large set of available SCY missions addressing a diversity of socio-technical problems for learners worldwide. Learners sometimes work on their own to find an (intermediate) solution, sometimes provide feedback to products of other students or ask for feedback on their own products from all students on-line, sometimes work together in real time on a shared object while communicating through the chat facility, find products of other students to work on in the database of ELOs, hand in their intermediate products through their portfolio to

their teachers, create common solutions to the problems posed and present the final design to an international forum. Apart from learning about the domain and inquiry processes, these students gain an international cultural experience, they share problems with others and discover that solutions are not just technical but also have a cultural aspect, they practice their languages (assuming that English would be the language of communication), and they learn how to collaborate with students with different backgrounds. As an example of cultural as well as technical exchange, we can consider one of the missions developed in SCY that concerned the design of a climate-friendly house. The design of such a house requires a completely different approach in Estonia as compared to Cyprus, two countries with SCY partners. Students from these two countries who are working together learn about cultural differences; they also deepen their domain knowledge because they have to think of very different solutions to the same problem. One step further, the problems that students work on could be real problems that engineering companies face, so the results may contribute to real solutions in real situations.

This ideal picture is not as simplistic and straightforward as depicted here. First, language would be an issue. For many students, certainly for those at a young age, their English proficiency is not sufficient for full international cooperation. For this reason all SCY missions also exist in different local languages. Second, societal assignments as they are used in SCY require students to work for 16-20 hours. Such an assignment does not fit in all curricula; many national curricula also do not foresee an integrative treatment of domains such as is pursued in SCY missions. Third, teachers need to be prepared for this pedagogical approach. In SCY we have created a so-called 'teacher dashboard' on which teachers can see the development of students in their group. On the basis of this information the teacher can decide to tweak the triggering of scaffolds for students or can interfere directly in the students' work. Teachers need extensive training in inquiry learning to find the right balance between freedom for the students (e.g., to

maintain their self-motivation and feeling of ownership of the task) and providing them with structure (e.g., to keep them on task). Fourth, learners also need to get used to the ways of learning they experience in SCY missions. As an example, students often have trouble using ELOs from other students and need to be guided in fruitful and responsible re-use [see 5]. Fifth, and finally, from a technological perspective SCY would need a redesign to make it stable and student-proof. As is the case with R&D projects, innovation on the one hand, and delivering systems as extensive as SCY that are robust enough to introduce them at a wide scale in educational contexts on the other hand, are not compatible goals. Another round of development with a focus on simplification and technical stability would be needed to make SCY widely available for educational organisations.

The rewards of using SCY missions in education are multifaceted. Learning with SCY missions broadens students' perspectives. It does not free learners from learning basic science topics, but they can learn them in the context of a real problem that helps them see the relevance of the basic topics and presumably increases their motivation. SCY missions often require students to gather data in the real world with mobile devices, which implies that the classroom would extend to other places than just school. Performing these missions collaboratively would also help to strengthen students' social and collaborative skills (if supported adequately), which gives them better preparation for teamwork and for the actual workplace. Missions can even mimic real workplace situations, and in this way offer students a glimpse of potential job possibilities.

Although SCY is unique in some of its characteristics, it is not the only system offering students the opportunity to work on socio-technological issues in a learning context. Examples of other systems with similar objectives are WISE [6], or, in a European context, STOCHASMOS [7], but many similar initiatives can be found worldwide. This shows that there is a need for learning environments in which a pedagogy of inquiry, collaboration, and design goes together

with solving encompassing, socio-technological, multi-faceted problems, as we also see in problem-based or project-based instruction. It is crucial that scaffolding is present in these learning environments to guide students through the process; ideally, these scaffolds are adaptive to students' actions and knowledge level [see, e.g., 8]. Rapid progress is currently being made on this through developments in learning analytics, and several examples of this kind of adaptivity can be observed in SCY.





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## 4 Conclusion

Policy-makers and strategists worldwide recommend including inquiry learning in courses for students of all ages [e.g., 9]. In SCY missions, inquiry learning is combined with a contextual, societally-relevant problem and collaboration among students. This combination works quite naturally, and it helps students to acquire deeper knowledge, more relevant knowledge, and knowledge that can be shared with others. These three characteristics of knowledge (deep and versatile, applicable, and shareable) are exactly what modern society demands. In addition, learners will acquire the investigative and collaborative skills that will help them to function in new and unexpected situations. Finally, SCY missions, through their versatility and real context may help to keep students motivated.

The starting points of the SCY project align almost directly with the grand challenges for technology-enhanced learning as identified by Fischer, Wild, Zirn, and Sutherland [10]. In their book, the main themes for grand challenges are acknowledged as: *connecting learners*, *orchestrating learning*, and *contextualising learning*. *Connecting learners* is based on the idea that knowledge is best constructed in a social context. In SCY, learners share objects and communicate about them. In the larger context of the assignment in the mission, they may create a final solution together. Often teachers organise presentations at the end of the mission so that the final products can be shown and exchanged among a wider group. So, connecting learners is inherently present in SCY missions. *Orchestrating learning* means that teachers (or the system itself) can adapt the learning scenarios ‘along the way’. In principle, that kind of adaptation could be part of self-regulated learning (self-orchestration). SCY missions are characterised by an overall scenario that guides the student's route through the mission [3]. This scenario allows for flexibility in specific instructional scaffolds for students and in updating the overall route. These adaptations are automatically performed by the system or can be applied by the

teacher. To inform the teacher about students’ progress, the SCY system has a dashboard that shows the teacher how students are progressing. Teachers may intervene by changing components of the environment or by providing students with direct feedback. The system itself can also adapt to the learner. As an example, the system can warn students if they engage in unsystematic experimentation behaviour or may give students feedback on the correctness of a concept map that they have constructed. *Contextualisation* is also essential in SCY missions. The very nature of a mission is a real context. In the mission students may also interact with the real world, for example by collecting data with mobile devices and importing these data into the SCY mission.

European research delivers many learning environments that offer real and interesting challenges to learners. Because these environments result from R&D projects, they can almost always be characterised as prototypes, as should be expected. Although functional, they are often not robust enough to be scaled-up to real educational settings; their look and feel need a professional polishing, and maintenance is not in place. Professional technology-enhanced learning, as marketed by publishers, typically offers stable products that look attractive and that are well maintained. However, these products are often very conservative and do not offer students the challenges that the R&D products do. The chief task that faces us as researchers and teachers is to find a way to unite the best of both worlds and have stable, good looking, well-serviced, but still challenging technology-enhanced learning environments. This may require new ways of thinking from both sponsoring organisations (such as the EU) and professional publishers.

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## CHAPTER 3

# Reflective Learning at Work

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The goal of MIRROR is to engage knowledge workers in reflection on past work experiences in order to improve selected aspects of their work. Technology plays a mediating role, in that technology can provide an additional perspective on work experiences e.g. through log or sensor data or can support the documentation and exchange of observations and insights on work experiences. MIRROR aims to support reflective learning in self-regulated learning settings at work, i.e. without teachers or coaches present.





This addresses the fact that knowledge workers are expected to take the driver seat of improving their, their team's, and their organisation's work performance. The validity of this approach has been confirmed in user studies: All our study participants – carers, nurses, physio- and ergotherapists, physicians, IT and telecommunication white collar workers and civil protection volunteers and professionals – see reflection as integral part of their job description. MIRROR provides three key innovations. Firstly, MIRROR provides theory and tools that connect reflective learning at an individual, collaborative and organisational level. Secondly, MIRROR investigates the potential for technology support for reflective learning. Thirdly, MIRROR relates reflective learning to creative thinking in order to open up pathways to new solutions, and to serious games in order to experiment with alternative behaviours in new ways.

## 1 Introduction

In fast changing business environments where jobs and roles never stand still, the slow processes of creating formal learning materials and delivering vocational training across the whole organisation has proven prohibitive. In particular, small and medium-sized enterprises view current learning technologies as insufficient to support learning-on-the-job. MIRROR addresses the need for learning in day-to-day work and life: We cannot depend upon or wait for formal learning interventions if we are to improve. Improvement must be facilitated continuously and not only for individuals but also for teams, communities and organisations.

Typically, we learn from past experiences. By reflecting on those experiences, and putting them in relation to the current situation, we advance our competences and solve pressing problems. However, past experiences are a fleeting memory. We forget important aspects of the experience, remember things differently and above all,

*Movie 3.1 Stefanie Lindstaedt and  
Viktoria Pammer, Know-Center, Austria*



experiences are difficult to share with others. Just imagine training for a marathon: Data on your heart rate, step frequencies, surrounding terrain, and so forth provides a meaningful basis for assessing your performance and planning further trainings.

The overall objective of MIRROR is to give employees the tools and the motivation to reflect on past work performances. Personal learning can then occur in 'real-time', and pressing problems can be solved immediately in creative ways. Both traditional formal training (like school, university, professional training) and commercially available e-learning typically focus on transmitting existing and already explicated knowledge. A significant part of work-related learning is informal learning – tightly intertwined with work practices, the work place and the social structures at work [2].

Currently, e-learning and knowledge management technology focuses on transmitting explicit knowledge: E-Learning systems are built around digital artefacts such as slide presentations, written case-

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studies, videos, audio material etc. EU projects such as APOSDLE and MATURE for instance also investigate self-regulated learning in work settings. However, both projects focus on interacting with existing, explicit knowledge encoded in digital artefacts. MATURE acknowledges that there is a process of knowledge evolution that depends on input from its participants, namely knowledge workers. Within MIRROR, we go one step further by focusing on the learning mechanism of reflection itself, as the single most important learning mechanism for self-regulated learning. Reflection, which we use synonymously to reflective learning, means to critically review own behaviour, knowledge and attitudes and to be prepared to change either of these in the future – in order to “perform better”, against whichever goal has been chosen [1]. Only through reflection does learning-on-the-job and learning-by-doing become meaningful in knowledge-intensive work settings. Reflection thus leads to knowledge that, in turn, can of course be written down and then be used in traditional e-learning or knowledge management systems. Therefore, MIRROR does not seek to replace current learning technologies but to augment them.

MIRROR focuses on capturing experiences in real situations and providing this captured data as a basis for future reflection. We thus help you to remember experiences better. MIRROR also helps employees to increase their level and breadth of experience by observing the experiences of others. Within the MIRROR project, we look at how reflective learning happens in organisations *now*, and imagine how it *could* happen with technological support.

## 2 Survey of the current situation

Within five companies (testbeds), which we believe are sufficiently representative for the respective domains health care, social care, civil protection and (IT) consulting, we confirmed that reflective learning plays a significant role in current workplaces [7]. Individual employees, teams and management acknowledge that reflective learning is “part of the job description” and necessary for the acceptable performance of the organisations. The following is an example from the domain of IT consulting, where an individual employee reflects on his own professional development:

*“One day I [...] looked at the projects I had done. I mapped them onto our process map and tried to see which parts I have covered with my projects, where have I collected experience? What is missing? Doing this, I have learned again a lot, realized what I had achieved so far [...] and then I could say concretely that on the following three issues I really want to work on.” ([7], p.32).*

Reflective learning is however also a discretionary activity, i.e. not subject to work appraisals and formal job duties. This ties in well with existing argumentation that knowledge work is a discretionary activity [3] however relevant it is for organisations to succeed. In a knowledge society, it is and will continue to be highly relevant for organisations to engage employees in reflective learning with respect to work practices. Our studies also point to the fact that reflective learning takes place in a broad variety of settings, like “at home”, “in handover meetings” or “during task performance” (see [7], p.33). The implication is that organisations and technology should support reflective learning in all these settings, and, more to the point, the transfer of results of reflective learning in these settings to the organisational body of knowledge.



### 3 MIRROR Key Innovations

MIRROR is the first EU project that investigates technology-enhanced learning that can be used in work contexts where no teachers, no formal content, and no explicit knowledge are available. MIRROR innovates research on reflective learning by the following three aspects:

1. *Reflective learning is individual, social and organisational:* Reflective Learning is individual and social, and it ensures the organisation's success. However, theory about reflective learning so far does not connect these three levels. The MIRROR model of computers-supported reflective learning provides a grounded theoretical basis for understanding and supporting individuals, teams, communities and organisations to learn from experience and to communicate insights.
2. *Reflective learning can be supported by technology:* Technology can make it significantly easier for individuals to learn from experience. The exact role and benefit of technology for reflective learning is under investigation within MIRROR: We are the first ones to be able to sum up: What can technology do to make learning from experience more likely to happen and more efficient? The key distinction to other learning approaches is, that MIRROR captures data representing work performances, makes it available for reflection and gives advice based on this data. For instance, the KnowSelf App [6] tracks how knowledge workers spend their time. The KnowSelf App helps people to analyse these recordings and to identify harmful or simply unintended behavioural patterns. Researchers also investigate, how the KnowSelf App can give advice based on the capture data: What aspects of time management should you pay attention to, and how can you go about improving your time management and work performance?





3. *Reflective learning connects to creative thinking and experiential learning*: MIRROR also connects learning from experience to the creation of new knowledge and the experimentation with alternative behaviours: To ensure, that different paths can be taken in the future, you need to engage in creative thinking. In some cases, alternative behaviours cannot be safely trained in real situations – for which case MIRROR provides serious games.

MIRROR bundles Apps in domain-specific app suites (see Table 3.1). One example is the health care app suite, which provides reflective learning Apps to nurses and physicians. The health care app suite contains an App that guides the vocational training of medical specialists, helps nurses embed theoretical knowledge within daily work practice, and helps physicians to document, analyse and where necessary improve their conversations with patients and relatives of patients.

## 4 Conclusion

MIRROR is the first EU project that investigates technology-enhanced learning that can be used in work contexts where no teachers, no formal content, and no explicit knowledge are available. MIRROR connects reflective learning at an individual and collaborative learning with the organisational level to ensure the success of all players: the individuals, the team and the organisation. MIRROR also connects reflective learning to creative thinking and experiential learning, to ensure that alternatives to well-known paths are thought of and experimented with.

We as a society already realise the need for lifelong learning, and the increasing importance of self-regulated learning. Reflective learning, in combination with creative thinking and the opportunities to experiment with new knowledge and behaviour in ‘safe settings’ is the core mechanism to achieve both. Successful individuals, teams and

organisations already live this. MIRROR will support us as a society to systematically engage in reflective practices. Thus, we will be more effective – by avoiding making the same mistake twice - and more adaptive – by constantly reviewing our actions and results.

*Table 3.1 Key results of the MIRROR project.*

- ❖ The MIRROR model of computer-supported reflective learning. A model that relates stages within the reflective process to technology support has been published [5]. MIRROR also researches what are specific reflection activities at work, and the interleaving of individual and collaborative reflection at work, that may lead to individual, collaborative or organizational learning.
- ❖ A technological framework, called MIRROR Spaces Framework: It is based on XMPP technology that enables a managed data exchange between applications. It is available for MIRROR applications as well as externally developed applications. A description of the framework is available online: <http://mirror-project.eu/work-packages/interoperability-framework>
- ❖ Specific reflection Apps which are developed in close cooperation with MIRROR’s targeted end users during the project. These Apps are designed to support reflection. Existing MIRROR Apps can be found online (description and often also download): <http://www.mirror-project.eu/showroom-a-publications/mirror-apps-status>.

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## CHAPTER 4

# Social Creativity at Work

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Nowadays the enterprises are asked to move towards a continuing education paradigm with the prospect of better supporting the development of their employees professionalism at all operative levels inside the enterprise. For this purpose, it is necessary to apply an approach based on lifelong learning for continuous professional development.





The ARISTOTELE project has been implementing a methodological and technological solution, based on semantic web technologies, that anchors training activities to the working context, through the reinforcement of links between individual and organizational learning, and innovation processes within the organization.

According to this view, it will be possible to implement the future work environment, where functionalities intended to support the learning may be tightly integrated within it, together with functionalities supporting work activities. Such an environment will make easier the exploitation of the organization collective knowledge, and the contribution to it, as well as the transformation of tacit knowledge into explicit knowledge.

## 1 Introduction

The ARISTOTELE project has been focusing on the development of methodological and technological solutions for reinforcing links between individual and organizational learning and creativity within knowledge intensive large and medium enterprises [1]. A knowledge-intensive organization is an organization where the majority of employees are highly educated, where ‘production’ does not consist of goods or services, but in complex non-standardized problem solving.

The current technology solutions for enterprises, and especially solutions related to learning and competency development, do not provide effective answers to enforce these links, furthermore, such solutions, with the loosely coupled integration of different subsystems (i.e. human resource management, learning, collaboration, process management), prevent from gaining advantages in terms of performance, quality of work, easy collaboration and knowledge flow within the organization.

*Movie 4.1 Chiara Giorleo, MOMA SpA.*



ARISTOTELE follows an approach that supports a joint exploitation of human resource management, organizational learning, knowledge management, and collaboration processes. The proposed approach allows to create a virtuous cycle where intangible assets (creativity, competences, and knowledge) are tracked, collected, and exploited through processes (organizational, learning, and social collaboration) whose central role is played by both users and enabling technologies.

In order to achieve this vision, the ARISTOTELE project provides the following key contributions:

- A new way of conceiving and enhancing the relationship among knowledge flows, organizational and learning objectives, work practices, and creativity within knowledge intensive organizations;
- A methodological and modeling ground consisting of conceptual Models representing, in a machine understandable way, key organizational assets and a set of business process patterns related to knowledge intensive organizations;

- Innovative methodologies processing, managing and operating on semantic conceptual models to support the achievement of organizational and performance objectives;
- An innovative technological platform: human centric; models & methodologies driven (in contrast with technology-driven); built on top of state of the art solutions, i.e., Intelligent Web Teacher (IWT) and Microsoft Sharepoint 2010.

The accomplishment of the ARISTOTELE's vision requires facing several challenges in different research areas.

In fact, the ARISTOTELE project has been developing a digital work environment that is characterized by several features supporting the knowledge workers during their daily activities. In order to develop such an environment ARISTOTELE bases on the definition of High Performance Workplace [13] and the concept of Personal Learning Environment and its extended view introduced in [14]. When developing such an environment the main challenge to be addressed consists in having an effective knowledge sharing, precisely enabled by the Knowledge Building ARISTOTELE services. These services can orchestrate methodologies able to foster the common semantic lifecycle (i.e. preparation, updating and maintenance of organizational knowledge according to data produced by the employees during their daily tasks), in order to face a challenging exploitation of huge amounts of information, which the knowledge sharing paradigm implies and that is introduced by the Enterprise 2.0 applications.

Building on top of this underlying layer of knowledge building, the ARISTOTELE working environment integrates the tool, with the purpose of supporting:

- *Learning at workplace.* For many organizations, the current state of learning at workplace is such that there is a focus on the design of formal content-rich courses, provided to end-users, as well as managed, tracked and monitored in command and control systems

like Learning Management System (LMS). However, [2] also asserts that all individuals usually learn informally at their workplace all the time while carrying out their work activities. A key challenge is that the organizations are trying to 'formalize' or manage the informal learning, though the individual only can actually 'manage' this, and let the organizations or systems enable and support the process with no direct control.. For this purpose, ARISTOTELE contemplates a computational work environment supporting a work-integrated Intentional Learning (from Formal to Informal).

- *Human Resource Management.* The ARISTOTELE project investigates HRM from the following perspectives: relevance analysis, competence gap analysis, and team formation. In particular, the relevance analysis is addressed as an application of the Viable System Approach (VSA) theory [3]; the crucial issue of competence gap analysis is approached as a need for HR departments to match required and acquired competencies in order to find suitable candidates for tasks and projects [4]; the problem of creation of competence-based teams is also faced, specifically focusing on a disregard of the state of art that takes into little consideration personal traits [5] and social relationships among workers of an organization, including trust.
- *Innovation and open innovation.* ARISTOTELE has been investigating the research work that deals with defining a more operational open innovation. In particular, it addresses the current research challenge, which focuses on the use of information from the collaborative system to manage innovation. Particularly relevant from this perspective is the notion of participatory design as a collaborative process and, even more, the Computer Supported Collaborative Design (CSCD). For this purpose, ARISTOTELE is investigating the use of Recommender Systems (RS) supporting collaboration [6]. The initial findings show that RS have positive effects and can stimulate the collaboration also increasing the success rate in workers' objectives achievement.

## 2 The innovations of ARISTOTELE

The ARISTOTELE project introduces innovations at different levels: models, methodologies, and tools, see [Figure 4.2](#).

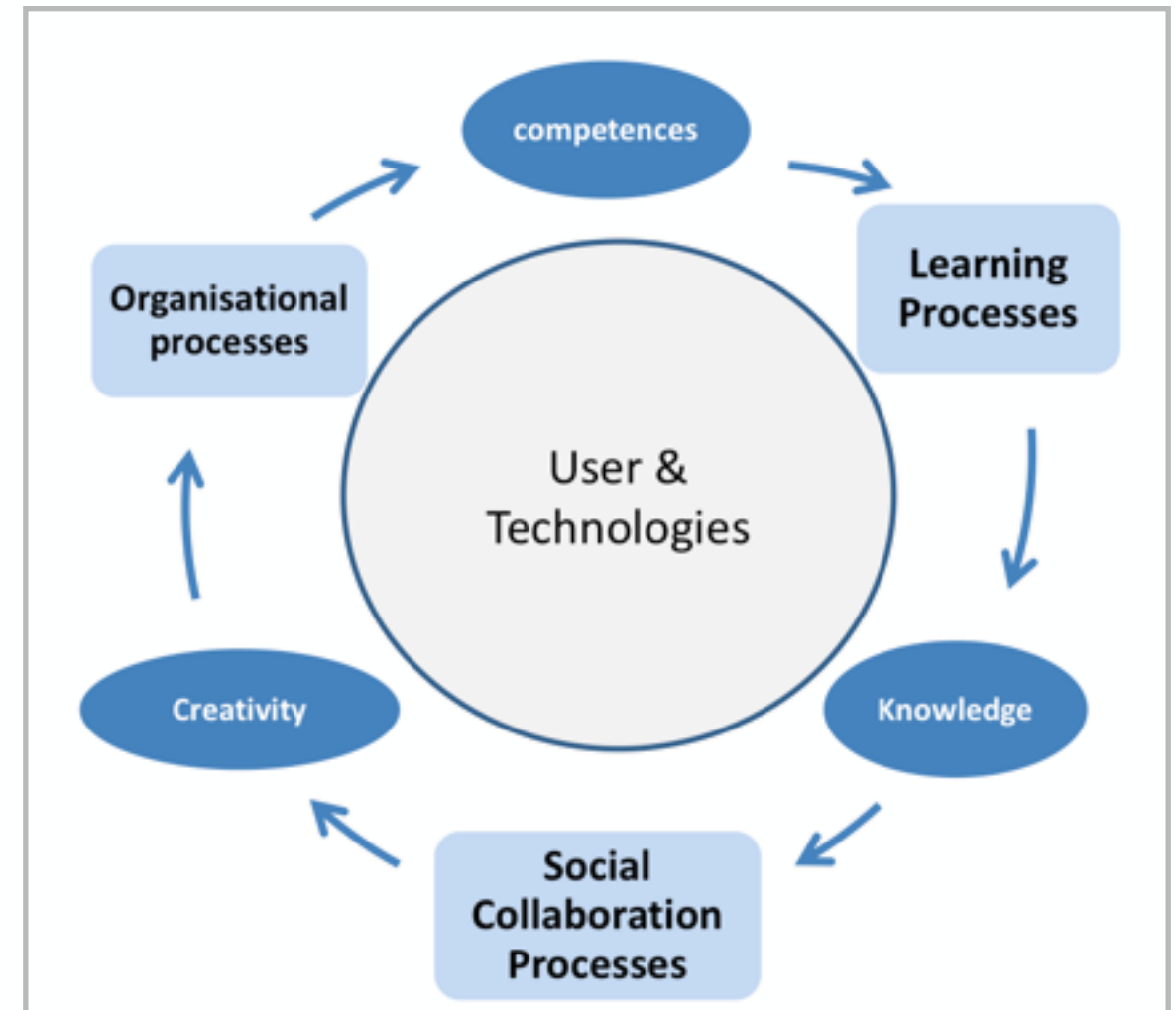
The ARISTOTELE semantic models, which the ARISTOTELE methodologies are based on in order to perform their processing, are at the bottom level. The ARISTOTELE tools are on top of models and methodologies and implement such methodologies.

In particular the ARISTOTELE models, methodologies, and tools introduce key innovations in the following organization areas: (i) Learning and Training, (ii) Human Resource Management, (iii) Collaboration, (iv) Knowledge Management, and (v) Innovation.

The learning and training processes are going to be improved by tailoring them to knowledge worker's needs and expectations. More in detail, ARISTOTELE has introduced the Methodologies for Learning Experience Generation (MLEG) that allow to define personalized/ contextualized learning environment that, from time to time, reflect motivation, context, strategies of both workers and enterprise and are focused on specific competences to be developed. The defined methodologies address three forms of learning as proposed in [7]. The MLEG provides an answer to issues concerned with the generation of the most suitable learning experience for the worker, finding the best way of learning at workplace balancing among the specific competence to be developed, the context, the available resources, the organizational strategies needs, workers' personal needs and objectives, workers' learning styles and motivation (from formal to informal).

In the ARISTOTELE project, the Human Resource Management (HRM) is centered around the competence concept that supports: competence gap evaluation, team formation, human resource development, recruitment. Furthermore, a novel application of the Viable System Approach (VSA) has allowed to design a relevance

Figure 4.1 ARISTOTELE virtuous cycle

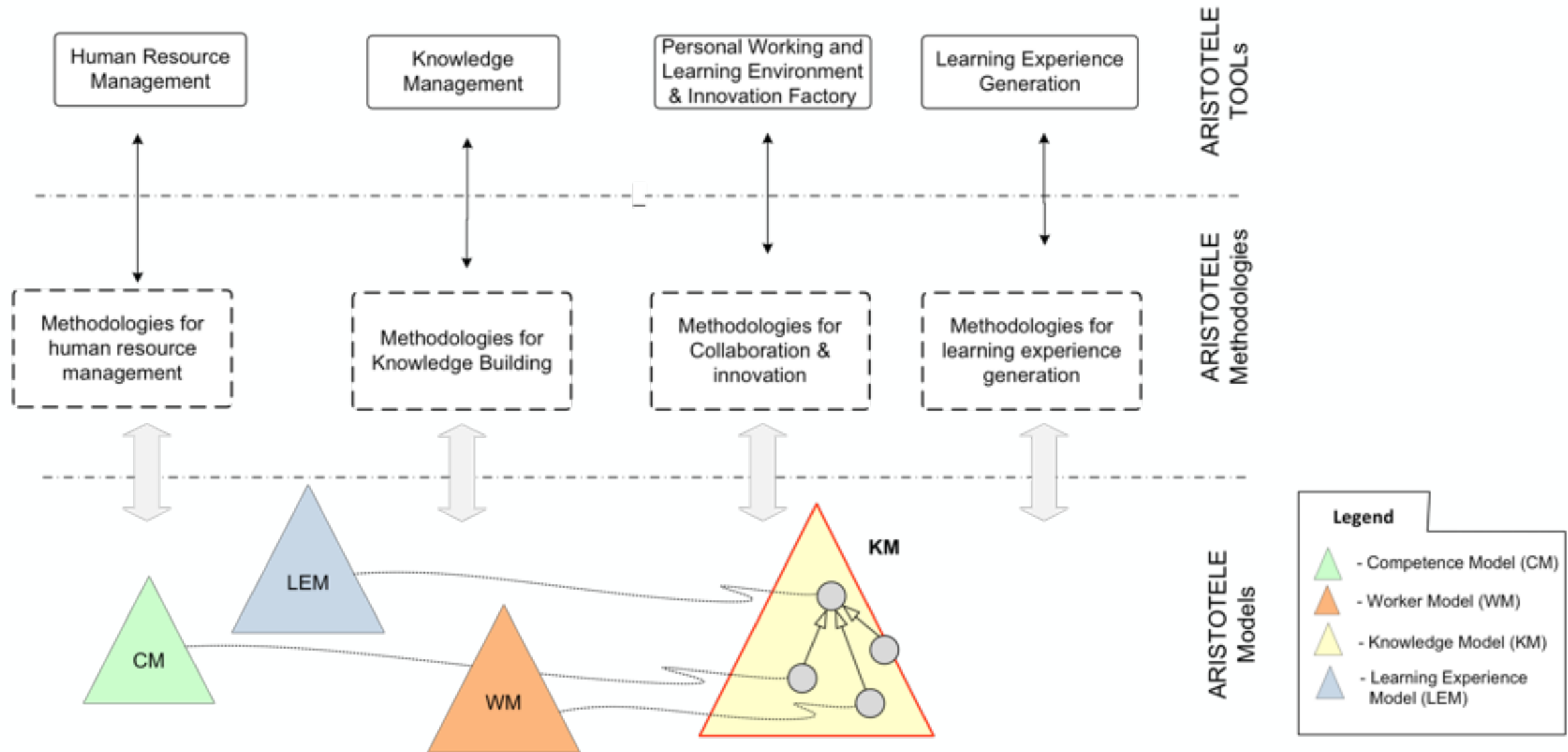


analysis solution which may help make decisions regarding HR processes such as rewarding, succession planning, personnel reduction, and job redesign as described in [8]. Another distinctive feature is the importance given to social aspects such as trust and innovation in team formation and human resource development. Finally, as part of the recruitment module a tool for the automatic analysis of Curricula Vitae has been introduced, that provides information on personality traits on the basis of the Myers-Briggs Type Indicators (MBTI), RIASEC and BIG FIVE models.

The ARISTOTELE project is expected to improve the collaboration among workers within the organization using both social approach and



Figure 4.2 ARISTOTELE models, methodologies, and tools.



knowledge sharing. For this purpose, a proper environment has been introduced, the Personal Working and Learning Environment (PWLE), that facilitates the knowledge sharing process, introducing a specific definition of context helpful to identify a scope for each tool used within the PWLE. Through this scope any data resulting from the use of tools is enriched with additional information, that are used to support the identification of relations among entities, and to enable the process of knowledge exchange between worker and organization (and vice versa).

The ARISTOTELE project has firstly defined some methodologies for the knowledge building (afterwards also implemented) which enable specific processes for the exploitation, population and updating of ontology-based knowledge base within the ARISTOTELE platform. The main methodologies defined are the following: knowledge extraction, ontology and instance matching, ontology merging. They have been defined following the approach based on the pipe concept, that is constituted by interconnected though autonomous pieces, so that they can be used in a modular way, allowing for their orchestration and

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support to several processes (e.g. task execution, update of collective knowledge, etc.). The methodologies have been designed and evaluated in ARISTOTELE, in a specific and original manner, by using existing or improved algorithms (e.g. fuzzy formal concept analysis, and fuzzy clustering) [9] and as far as possible by available technologies (for example: Apache Solr, Apache Lucene, and Silk). The intelligent features of knowledge building methodologies are enabled by the ARISTOTELE models standing at the basis of the semantic layer [10]. Four models have been defined by the ARISTOTELE project: Competence Model; Worker Model; Learning Model; Knowledge Model (that cover all the organizational aspects). These models have been defined following a process based on three cornerstones: (i) derivation of main concepts from methodologies' needs and project requirements, (ii) definition of modeling principles, (iii) analysis and selection of existing specifications that the ARISTOTELE models have been built on [see 16, 17].

ARISTOTELE is also expected to foster Innovation Factories (IF) by developing a collaborative system, to design innovative products and understand how to construct learning suggestions fostering the development of these new products. The ARISTOTELE Innovation Factories leverages on a special incarnation of the ARISTOTELE Recommender System (ARS) that permits to introduce a serendipitous effect in the design work, as well as facilitate the disclosure/detection of latent knowledge and interests of innovation team members [11]. The ARS is an example of a new category of recommender tools called Human Resource Recommender systems. The ARS reacts to a stimulus (e.g. a task, a commitment of the organization, etc.) by verifying the gap (in terms of required competences) between organization resources and the stimulus, then, giving not only suggestions correlated to that stimulus, but also suggesting a set of alternatives that, at a first sight, could seem completely unrelated, even though, looking at past experiences, they could have a positive influence on the process of knowledge improvement. Proceeding in

this way ARISTOTELE can introduce a novel and unexpected knowledge in the organization that is able to foster creativity and innovation. Such an approach is often mentioned in literature as an implementation of the notion of serendipity, i.e. “discovering something you were not looking for”.

All these innovative features have been validated under the adoption acceptance and assimilation perspectives. From the adoption perspective, a survey involving 120 European knowledge intensive organizations has been executed. With the survey also work-practices on team collaboration, knowledge sharing and innovation development within these organizations have been verified. As for the acceptance and assimilation perspectives in the same survey, we have collected some feedbacks about the software capabilities the platform is able to provide in the 5 ARISTOTELE areas (HRM, learning, collaboration, knowledge management and innovation). An average score ranging from 5.5 to 6 on a 7 point likert scale has been achieved in all areas. More in depth, an investigation on both acceptance and assimilation have been executed within the 2 project Pilots organizations. Either usability tests of single platform tools or a more general user validation, involving different systems' actors (HR manager, team leader, knowledge worker, etc.), have been executed with very promising results looking at their prototype nature (average SUS score for the different tools being above 70).

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### 3 A possible future

The ARISTOTELE project envisages a future where functionalities supporting work activities (e.g. goal and task management, trust based team formation, expert finding, CV analyzer, etc.) are integrated into a common digital environment that helps seamless and continuous collaboration and knowledge sharing, using technologies which enable formal and informal learning. This combination will make possible to support the process of professional growth within the organization through a lifelong learning approach, aligned with the organizational objectives and within the individual work environment.

Consider, for example, the following scenario (extracted from the ones utilized for the elicitation of the ARISTOTELE requirements, see [15]). AMIS has to define a new product proposal about on-demand television. The Human Resource Manager is asked to identify the best employees to be involved in the team that will have to define the new product and the related requirements. The system will suggest possible employees having the right mix of technical and behavioral skills (e.g., problem-solving, critical thinking, reflection, etc.) by using the semantic modeling of worker profiles basing on knowledge, skills, attitude and mutual trusts, as described in [12].

At the same time, the system identifies potential competence gaps of the proposed employees with respect the objectives targeted by the team, and defines suitable learning objectives to cover the gap. Taking into account both learning objectives and the employee's characteristics (e.g. their preferences, cognitive state, etc.), the system will generate a set of learning activities (they could be a course or training on the job, etc. depending on the objective and on the worker's learning preferences).

The designated learning activity will become part of the work activity and will be also supported by discussions shared through collaborative and social tools. Furthermore, the workers will take part into

brainstorming sessions in order to generate and select promising ideas for the new products/services. For this purpose they share materials (such as documents, articles, blog posts, tasks, etc.) found out among the existing knowledge in the organization being independently annotated by different workers with elements of the organization taxonomies and allowing to cross-relate them and to make them searchable. The analysis of the available material, has shown that the health sector will be one of the most promising in the next future and that there is still a lack o technologies specific for the online self-care. The team continues to develop and refine the requirements to define a specific health service via on-demand TV.

It is worth mentioning that the knowledge building capabilities available in ARISTOTELE are used for classifying and automatically annotating resources produced by the workers during brainstorming sessions (or more in general during their work activities). This means that when another worker starts working on a Project Y and collecting info and organizing his/her work (in terms of tasks, objectives, etc.) the system is ready to suggest possible workers (or other assets of the organization) that are related in some way to the same taxonomies' concepts previously used to annotate tasks, objectives, etc.

To sum up, ARISTOTELE enables the Learning Organization and supports the Organizational Learning development.

The implementation of such examples of scenario will provide a clear advantage from several viewpoints:

- *Economic*: the organization will be more efficient counting on a better exploitation of its human and intangible resources (hidden knowledge existing within the organization). In fact, whether the available tools have increased availability of information, a deluge of information, difficult to manage, represents a real drawback, specifically, the lack of management implies high costs for the enterprise (loss of productivity, duplicated efforts, poor decisions making, ...).



- *Educational*: the semantic web will enhance learning and collaboration in line with an interactionist perspective of socio-constructivist matrix. Furthermore, the capabilities, enabled by Semantic Web languages and patterns, as described in the above scenario, allow the activation of transformative processes that drive the transition from tacit knowledge to explicit knowledge as defined by Nonaka and Takeuchi's SECI model.
- *Technological*: the technological solutions introduced in order to achieve the depicted scenarios are based on some existing robust solutions for adaptive and personalized learning (Intelligent Web teacher Platform), Social Collaboration and content management (Microsoft Sharepoint 2010) extended with technologies for the knowledge building. These platforms represent the foundations for building applications in several domains. Furthermore, the access to these functionalities will be provided through a light weight application to be deployed client -side following the paradigm of web apps, which are expected to be even increasingly adopted in view of a wider spread of tablet and mobile devices.

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## 4 Conclusion

The results from the ARISTOTELE project represents a significant step towards the implementation of the learning organization paradigm, which is achieved by fostering collaboration, joint competency development, innovation, learning and knowledge development in an integrated manner.

On its way to achieve the expected objectives, the ARISTOTELE project has been contributing to the following Grand Challenges:

Interest –driven lifelong learning: the ARISTOTELE platform allows to catch information about how the workers can define their trajectory path in order to solve problems by: tracking objectives and tasks – and relations among them - defined by the workers; correlating documents learnt while performing work activities; maintaining information about experts contacted to contribute to the performed activities; etc.

The perfect PLE – Conceptual Considerations: the MLEG, defined and implemented in the context of the ARISTOTELE project, supports the generation of a personalized learning experience that, in the personalization process, takes into account: prior/background knowledge to be accounted; learning design that better supports a personalized learning; level of competence to be reached.

Bridging informal and formal contexts to create a unified learning landscape: the ARISTOTELE platform includes an LDL (Linked Data Layer) that correlates among them different pieces of knowledge. This underlying infrastructure, exploited by the knowledge building features, facilitates a reuse of knowledge created in informal contexts in order to be exploited in formal ones.

Semiotic recommender systems for learning, collaboration and creativity: one of the main challenge faced by ARISTOTELE is to efficiently manage the information deluge available within the organization, and to find proper information among this deluge, according to specific needs of the worker.

Powerful approaches for online collaboration: the ARISTOTELE platform provides powerful features to support collaboration. In particular, they are applied in: (i) the learning context, by enabling an adaptive collaborative learning environment based on conversations and on exploitation of resources available within the organizational knowledge base; (ii) the definition of a collaborative development approach based on the provision of an environment (the innovation factory) that facilitates the involvement of experts in the design of virtual products.

The ARISTOTELE Consortium has a strong commitment to exploit the project results from both the research and commercial point of view.

In order to facilitate the commercial exploitation, the project gives the utmost relevance to potential issues related to the adoption of the ARISTOTELE technology. In order to overcome possible barriers to the adoption, the project has been addressing the initialization problem, related to the need for populating the system, with information available within the organization which exploit the existing data sources. Connected to this problem is also the management of coherent updates of the ARISTOTELE system (e.g. models, organizational ontologies, etc.) according to the evolution of the knowledge produced during the workers' daily activities.

Focusing on future evolutions of the ARISTOTELE results, the commitment concerns a massive extension of the current methodologies and tools for the knowledge building and recommender systems in order to support the creative processes within the organization through innovative approaches that correlate activities, workers and contents. Finally, the results related to team formation will be further extended in order to find the best group of workers that can build a creative group.



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## Acknowledgement

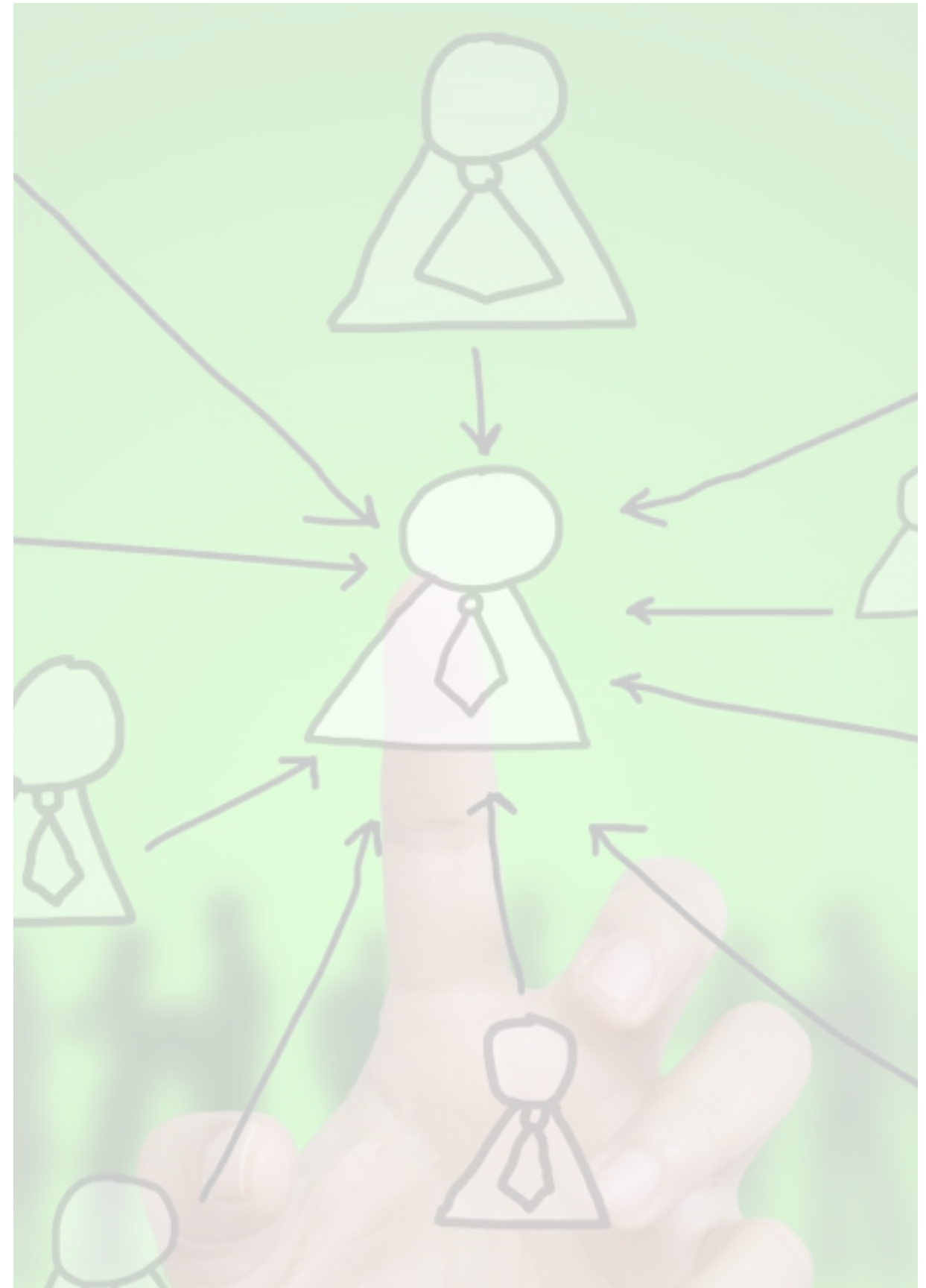
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## CHAPTER 5

# Classroom Learning Diagnostics

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While the technology-rich classroom makes it comparatively easy to gather, store and access data on students' activities, turning the data into information on learning that can inform pedagogical decision-making is still hard to achieve.

In the NEXT-TELL project, we build on concepts from educational assessment design and on modeling concepts from computer science as a basis for generating quality data on students' learning.



We describe a set of inter-related methods and software components that can be used to turn assessments into support mechanisms for learning, and that can make use and sense of data for improving teaching and learning.

## 1 Introduction

Schools are slowly yet inevitably entering the information age. But while the level of technology infusion is increasing, and with it the capacity to distribute information for learning and gather information about learning quickly and efficiently, we are still far away from the vision of the school as a “high performance, personalised learning community” [1].

The barrier is not so much the absence of information, but the absence of *the right information, at the right time, in the right format*. The classroom may be increasingly data-rich, but it is still comparatively information-poor. One reason for this is that a good part of the data made available to teachers and students have limitations for informing pedagogical decision making: Large-scale assessment data are not usually linked to classroom practices and outcomes, and are not available to the learning and teaching activities in a timely manner [2]. Furthermore, classroom technologies that are closer to real-time performance tend to focus on activity tracking rather than on knowledge changes.

For instance, classroom response systems, also known as ‘clickers’, are an effective way for teachers to obtain instant data about students’ thinking, and are also easy to use. However, classroom response systems do not guide the teacher in formulating the ‘right’ questions, such as questions that can help to identify residual misconceptions in students. Moreover, even if high-quality real time data on students’ learning in the classroom were available, there would still be issues of teacher capacity. Some studies report that many teachers have views about the nature and the role of evidence that are not conducive to

Movie 5.1 Prof. Dr. Peter Reimann, MTO



data-oriented decision-making [3]. And even when teachers are appreciative of learning data, they often consider themselves insufficiently qualified to be working with detailed learning data; and/or lack the time to do so.

An important step towards making classroom data useful for teachers’ and students’ ‘tactical’ decision making (‘what to do next?’) is to express the information on the level of knowledge and skill development, processes of learning, motivation and engagement, instead of simply as activities and events. Teachers usually get this information from direct observations, and from formative assessments such as quizzes or problem solving exercises.

In the technology-rich classroom, a third source of information is the recordings of learning activities as they unfold in digital media, such as software applications (e.g. MS Excel), learning management systems (e.g. Moodle), and increasingly on ‘Cloud’ tools and services (such as Google Docs). While these digitally enacted learning activities are easily recorded (e.g. as log files), they usually need further processing



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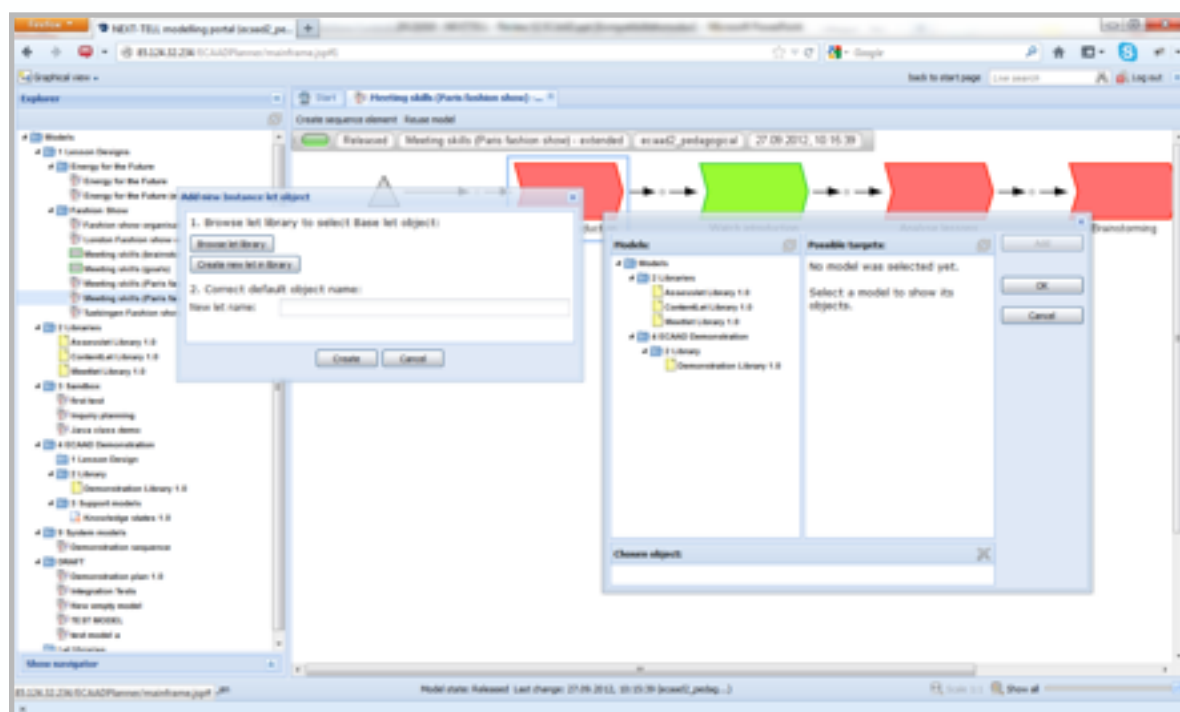
to become interpretable as information about learning and knowledge. So far, methods to do this automatically have often been in the context of intelligent tutoring systems and personalised learning systems [4]. From this line of research, we have learned what it takes to develop software that can diagnose changes to knowledge and skills. NEXT-TELL does not have the goal to develop fully-fledged adaptive teaching systems, but the insights gained in ITS research can be made available to teachers and students by focusing on the diagnostic capabilities of respective software.

In the NEXT-TELL project, we want to contribute to classrooms where ICT is used to engage students in meaningful learning activities, and to provide teachers and students with nuanced information about learning when it is needed and in a format that is supportive of pedagogical decision-making, thus optimising the level of stimulation, challenge, and feedback density. The project philosophy is that teachers should not only be seen as the users of classroom technologies, and the recipients of information, but also as the innovators of technology-supported teaching and assessment practices, and as the creators of knowledge about students' learning. The main research questions are: (1) What (real time) data do teachers need for monitoring their students' learning activities and diagnosing their knowledge development? (2) How should these data be made accessible and represented (visualised)? (3) How can the data be gained from students (including methods for automated tracing)? (4) How can machine interpretation of students' learning activities and products be integrated with teachers' workflows? (5) How can rich data on students' learning be used to inform decision making on the level of a whole school?

## 2 An open, model-based approach

Quality data on students' learning are not just 'found' in the classroom or in log-files, but need to be explicitly and carefully produced. Teachers are trained to glean information from observing students' reactions and from inspecting their work, in addition to performing formal and informal assessments (exam, quizzes, etc.). For the ICT-rich classroom, many of these observational and assessment practices need to be modified, and the data that become additionally available need to be integrated into teachers' practices. To facilitate this we build on a 'glass-box' approach to technology-enhanced formative assessment: both the diagnostic data transformation procedures and the resulting learner model should in principle be open. Beyond that, not only should the assessment be 'open', but it should also be the teacher who, in principle, can develop and modify technology enhanced classroom assessment methods. This also takes into account the fact that diagnostic information on students' learning can come from many sources: we consider in particular teachers, students, (in the role of self and peer assessors), parents, and software applications, which can all produce diagnostically relevant information.

An important consideration in NEXT-TELL is that all assessment methods, independent of who employs them (teacher, student, parent, software) should adhere to certain quality criteria, in particular concerning their validity and reliability. For establishing validity, we build on the Evidence-centered Assessment Design methodology [5], and for establishing reliability of assessments in NEXT-TELL assessment activities get (largely automatically) recorded. In short, we require that teachers as well as computational assessment services describe how they come to conclusions about learners' knowledge and skills, starting from observations about what learners do in the course of a learning activity, and from the artefacts produced in the course of a learning activity.



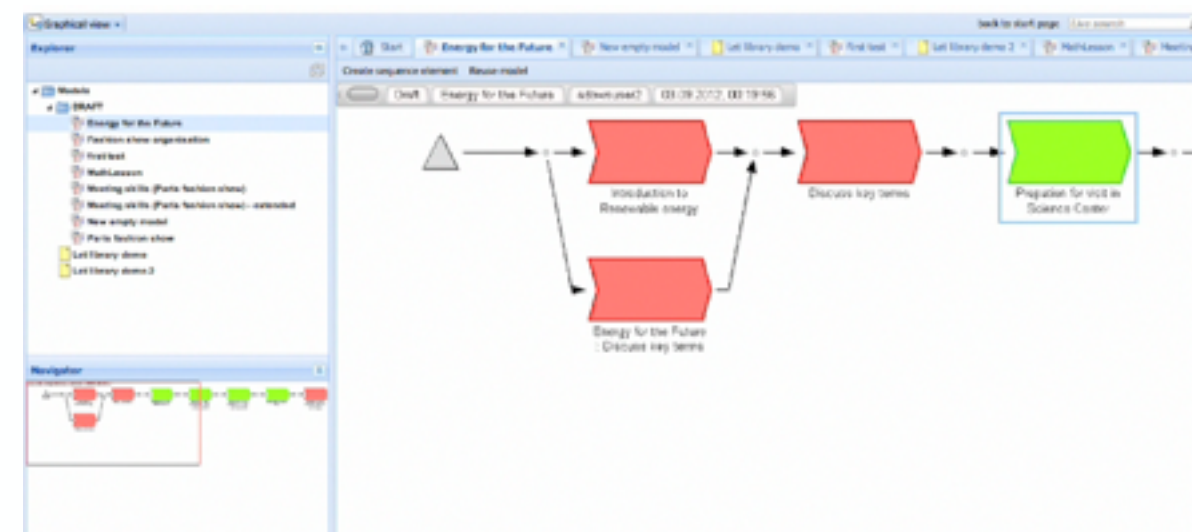
*Figure 5.1 User view of the ECAAD tool.*

*The ECAAD tool supports IT-enhanced learning and embedding of learning diagnostics. Learning activities (with or without IT) and assessment methods are represented as modules (the colored arrows) the user can select (from library on the left) and arrange in a temporal sequence. The dialogue boxes show how an activity is retrieved from the library and added to the current sequence. Depending on time, objectives, and expertise of the user, each of the modules can be further described and parameterized (the box in the front).*

To create assessment methods in a flexible yet rigorous manner, their inventors, including teachers, need to be provided with a ‘language’ to express their assessment ideas. If, as in our case, the assessment is of the formative kind, it needs to be integrated with the teaching/learning process. Therefore we equip teachers with an authoring tool for designing learning activity sequences and for relating these to expected knowledge changes (learning progressions) as well assessment methods (see [Figure 5.1](#)). We treat any assessment process as an instantiation of an assessment model, and any learning activity sequence as an instance of a learning sequence model.

Technically, we use a meta-modelling shell and the Open Models approach [6] for modelling formative assessment processes and learning activity sequences. The models are not only descriptions, but can also serve as the basis for rapid deployment in an ICT environment. Currently, we provide adaptors to Moodle, Mahara, and to Google Apps. We call the method and the toolkit ECAAD, for Evidence-centered Activity and Assessment Design.

Once an IT-based learning sequence is described in such a model (and as a side effect stored on a server), it becomes shareable (e.g. between teachers), and it constitutes a basis for technical deployment. Since the model describes the learning activities in some detail (e.g. those involved in peer writing), the activities can be supported quickly in different software tools (e.g., Moodle, LAMS, Google Apps). Furthermore, since the models specify the data that should be traced and/or requested from students during learning, it makes it easier to automatically gather and interpret log file information in terms of students’ learning. Since such tracing data are sensitive with reference to trust and privacy issues, in NEXT-TELL all trace and log file data get



*Movie 5.2 The toolkit for Evidence-centered Activity and Assessment Design (ECAAD).*

stored in an e-Portfolio system (an extension of the open source tool Mahara), and are thus under student control. The student can control what to share in general, and what to share with the teacher for appraisal in particular.

Under certain circumstances, the assessment of process and/or product can be achieved automatically, so that teachers do not have to perform routine evaluations, and students can get feedback rapidly. For instance, in NEXT-TELL we employ variants of an automated diagnostic method called competency-based Knowledge Space Theory (cbKST) [4] that gets used to estimate likely knowledge states of students based on their performance on specific tasks. Implementations currently comprise diagnosis of skills regarding visualising tabular quantitative data (a typical STEM skill) and diagnosis of aspects of English as a second language. Space does not allow to describe the cbKST method and integration with, e.g., Google Spreadsheets in detail (for details, see [4]). Suffice to say that based on data from the learner, such as changes she performs to a spreadsheet, cbKST updates a probability distribution over a set of competencies or skills that are related to each other via a requisite (or ‘surmise’) relation. These probabilities are made available in an Open Learner Model in numeric and graphical formats as hypotheses about the learner’s current level of proficiency, for each competence or skill.

In other cases, the appraisal of work will need to be done manually (via self-, peer- and teacher-assessment). In all instances, appraisals of students’ work in NEXT-TELL are maintained in an Open Learner Model (OLM) [7], and made available to teachers and students in multiple modalities (two of which are shown in Figure 5.2). The OLM represents students’ proficiencies in terms of competences and standards. We distinguish in this system between appraisals that come from the teacher, the student herself, from peers, or from automatic assessment (such as from Moodle’s quizzing engine, or from our automatic skill cbKST diagnosis). Dependent on the source, the appraisals can be weighed differently; for instance, teacher provided

and automated appraisal might be weighted higher than self-assessment when calculating a summary value for a competence. Also, the ‘freshness’ of information is taken into account, with more recent information being weighed higher by default.

Furthermore, entries in the OLM are not only ‘open for inspection’, but also ‘open for negotiation’ between stakeholders (teachers, students, and possibly parents), with a special tool for supporting evidentiary argumentation. This is also part of the ‘quality assurance’ approach built into NEXT-TELL: By providing users with easy, but managed, access to diagnostic data, they can contribute to identifying

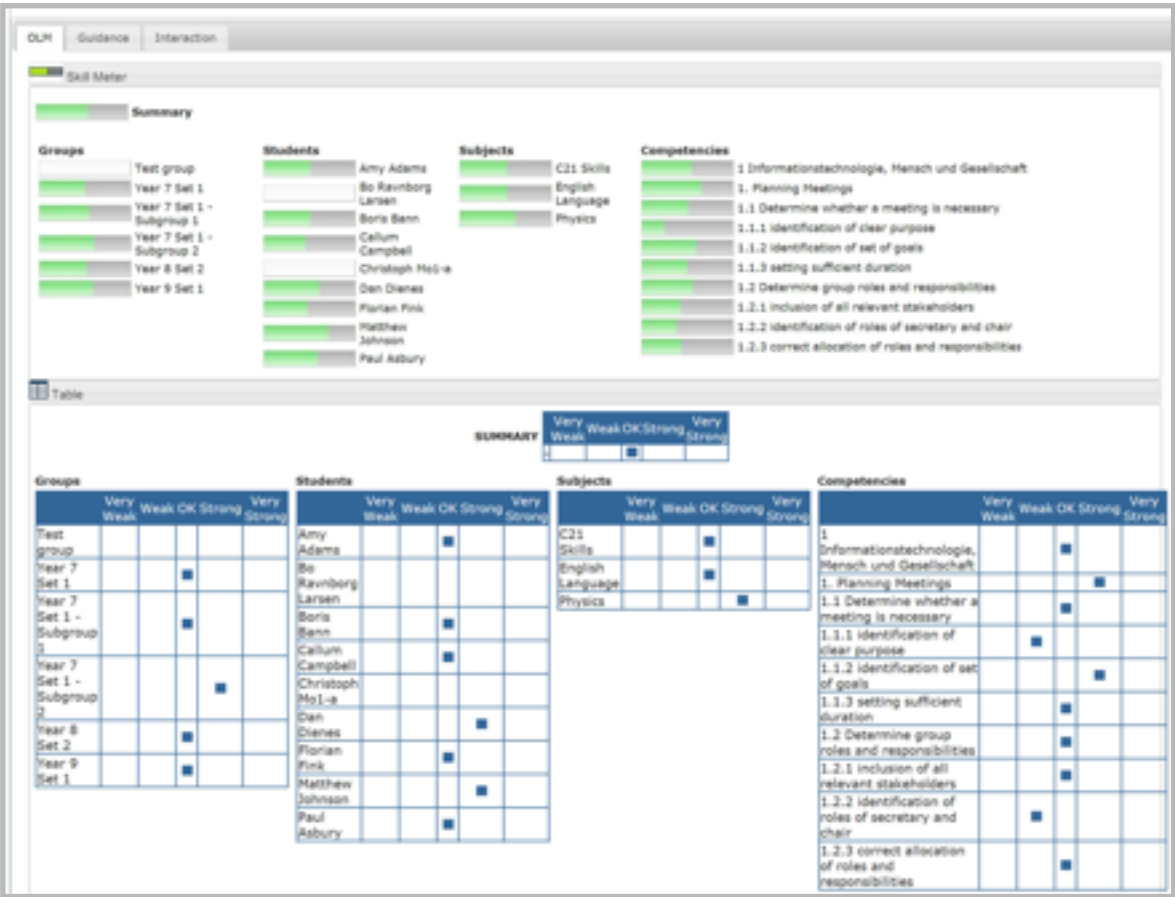
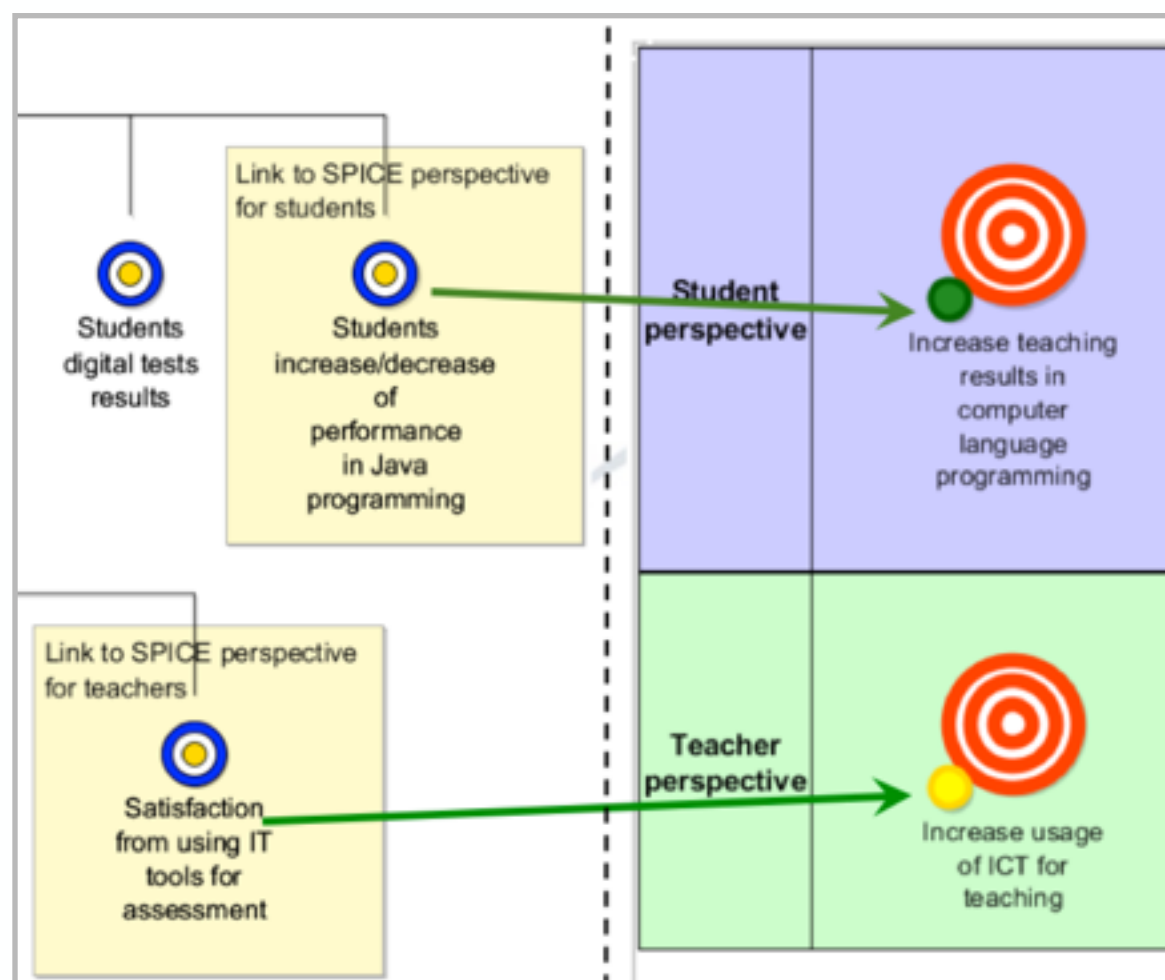


Figure 5.2 Teacher view of an Open Learner Model.

Part of the teacher's view of the NEXT-TELL Open Learner Model. The competences related information is displayed in multiple formats, two of which are depicted here.





**Figure 5.3** A part of The SPICE strategic planning toolkit interface.

*On the right-hand side strategic goals a school may have, on the left hand indicators that can be used to provide information on or monitor these goals. The data on the left can come from NEXT-TELL supported tools, such as Moodle, or from any other source, such as a school management system, that offers access to records in stores.*

inconsistencies and mistakes in the data. The OLM also stores an audit trail for each entry, a record of the steps that led to the current value of a competence variable as well as a record of the history of changes in that variable. These audit traces together with the information contained in the model of the assessment method (see ECAAD above) can also be used for automatic quality control: it can be

verified that a method was applied according to the model and it can be identified where deviations from the modelled process occurred.

Privacy and data security issues loom large for any technology that stores data on humans' performance in an individualised format. While with regard to corresponding technical solutions we rely on progress made in projects focusing in particular on such issues, 'philosophically' we have adopted a stance that is also used for ePortfolio systems: It is the student (or employee in life-long learning) who 'owns' the data, and it is under her or his control with whom to share what and for how long. In NEXT-TELL, it is also the user who controls what gets recorded and captured in the first place. In schools and universities, a teacher may request that certain learning-relevant activities are recorded and shared with the teacher, but the student has to agree to that, perform the sharing, and also decides when to stop it and when to delete records. Further research will be required to what extent this approach is fully practical, and to what extent it addresses users' concerns as well as wider legal and ethical considerations.

Quality data on students' learning are not only valuable for teachers and the students themselves, but also for school leaders. Arguably, all school decisions should be made alongside consideration for students' learning, including decisions regarding ICTs. To provide a direct link between strategic decisions on the school level and the rich data on students' learning made available in the Open Learner Model and the e-Portfolio, NEXT-TELL offers a strategic planning method, including tool support, called SPICE. SPICE (Figure 5.3) implements an approach to Balanced-Score Card planning suited to ICT planning in schools. We also support groups of Teachers Inquiring into Students' Learning (TISL), where the goal is to answer questions of relevance to a school's decision making, e.g. regarding the effectiveness of certain IT. Methods and tools are further described in deliverables and publications accessible on [the project website](#).

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### 3 The classroom of the future

The main arena in which NEXT-TELL wants to bring about change is the ‘classroom’. Somewhat paradoxically, if we — and others aiming for educational change — were successful, the classrooms will have disappeared, at least the classrooms of the ‘cells and bells’ format that is typical of 20th Century school architecture and pedagogical practices. Children and young people will still go to school, but will have different experiences than today. However, for the midterm future, classrooms with a single teacher with 20-30 students will still be the most frequent form of organised learning. But even within these constraints, many things can be improved, and the following are a few that we aspire to contribute to.

*The right level of cognitive density.* A study (financed by the Gates foundation) found that most school dropouts in the United States were (at least in 2006) due to boredom, not due to performing poorly [8]. In the future classroom, students will be less bored, but also less frequently over-challenged. Instead, most students will work at their optimal level of cognitive density: classrooms have become high-performance environments [2]. Teachers are supported by NEXT-TELL methods and tools to diagnose what that optimal level is and monitor it for relevant sub-groups or even for each student individually. Teachers are dynamically adjusting their teaching based on real time data on their students’ learning. For each student, they maintain an individual learning plan, agreed with the student and his or her parents. Students themselves are taking over significant parts of planning and monitoring of their learning, guided by their teachers.

*Teaching is a more collaborative practice.* While teaching a class may for a while remain an individual practice, preparing lessons, learning activities and assessments has become a largely collaborative practice. Teachers use lesson and assessment planners such as the

NEXT-TELL toolkit to develop learning resources in teams, within and across schools. IT-integrated lesson plans and assessments can easily be shared across schools as knowledge artefacts, and they can be implemented rapidly in different schools using different IT. All models and their components created with the NEXT-TELL planning toolkit can be searched and re-used, thus allowing the creation of user-driven open model libraries. Models can be annotated and commented on, thus creating a rich source of pedagogical knowledge. Models can be shared with teacher education institutions, thus providing a resource for training the next generation of teachers. In each school, some teachers are specializing in preparing digital resources, including NEXT-TELL models, as a service to their colleagues and the profession. These teachers do not only have sufficient IT knowledge, but also additional pedagogical and diagnostic knowledge that allows them to be innovators themselves, and to help their peers innovate their practices.

*Teaching has become a diversified profession and teachers are continuously improving their work practices.* Teachers collaborate in teams in and across schools to investigate questions regarding their professional practice. Teachers have become “connected educators” [9] who are tied into far-reaching Personal Learning Networks [10]. Some teachers have sufficient research knowledge to support their peers in school-specific and district-specific systematic research, for instance around the efficiency of digital whiteboards or into the effects of game-based learning. “Teaching 2020” is performed by a more diversified workforce than today [11], with career paths and specialisations that allow teachers to devote time to in-depth studies of students’ learning and development and identify implications for teaching practices and the use of ICTs. For this, they use professional research methods and tools, such as NEXT-TELL’s TISL method.

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*School leaders have matured from administrators to strategic leaders.* As such, they think of ICTs strategically: How can ICT benefit their school's students, and their staff? Using NEXT-TELL's SPICE method and toolkit for strategic IT planning, they formulate relationships between high level goals and IT, and identify indicators for measuring the impact of IT on their school's strategic objectives. While planning for ICT deployment, they align these aspirations with objectives for staff development, and formulate respective indicators. To manage their school, they no longer have to rely solely on generic data (e.g. attendance, grades, test results), but can use appropriately detailed and targeted information from their school's operation, for instance information managed in the NEXT-TELL Open Learner Model. School leaders share strategic plans and measurement frameworks with their colleagues in other schools, thus making a contribution to knowledge management and organisational intelligence.

## 4 Conclusion

We have described some of the core components of the NEXT-TELL project; more information, also on evaluations, is provided in [4] and in publications accessible on [www.next-tell.eu](http://www.next-tell.eu). Methods and tools are currently being further developed in close cooperation with teachers and schools in a number of schools across Europe. NEXT-TELL is a complex project because, in order to realise the potential of the technology-rich classroom, a whole school approach is needed. IT integration has to be supported from the top and serve a school's strategic goals (SPICE). Teachers have to engage (collaboratively) in what is for them new forms of planning learning activities and formative assessment (ECAAD), because of the demands of using technology in the classroom. To capitalise on the potential for IT for tracking, logging and monitoring, the technology needs to be deeply integrated into schools' workflows. All stakeholders, but in particular teachers and school leaders, need to engage in collaborative sense-

making, interpreting 'big' and 'rich' data of kinds that have not been available before (TISL). In fact, a whole school approach is what is minimally required to address Grand Challenges such as "New forms of assessment of learning in TEL environments" or "Making use and sense of data for improving teaching and learning", see [12]. More realistically, it will require alignment across all levels of educational systems, including the policy level.

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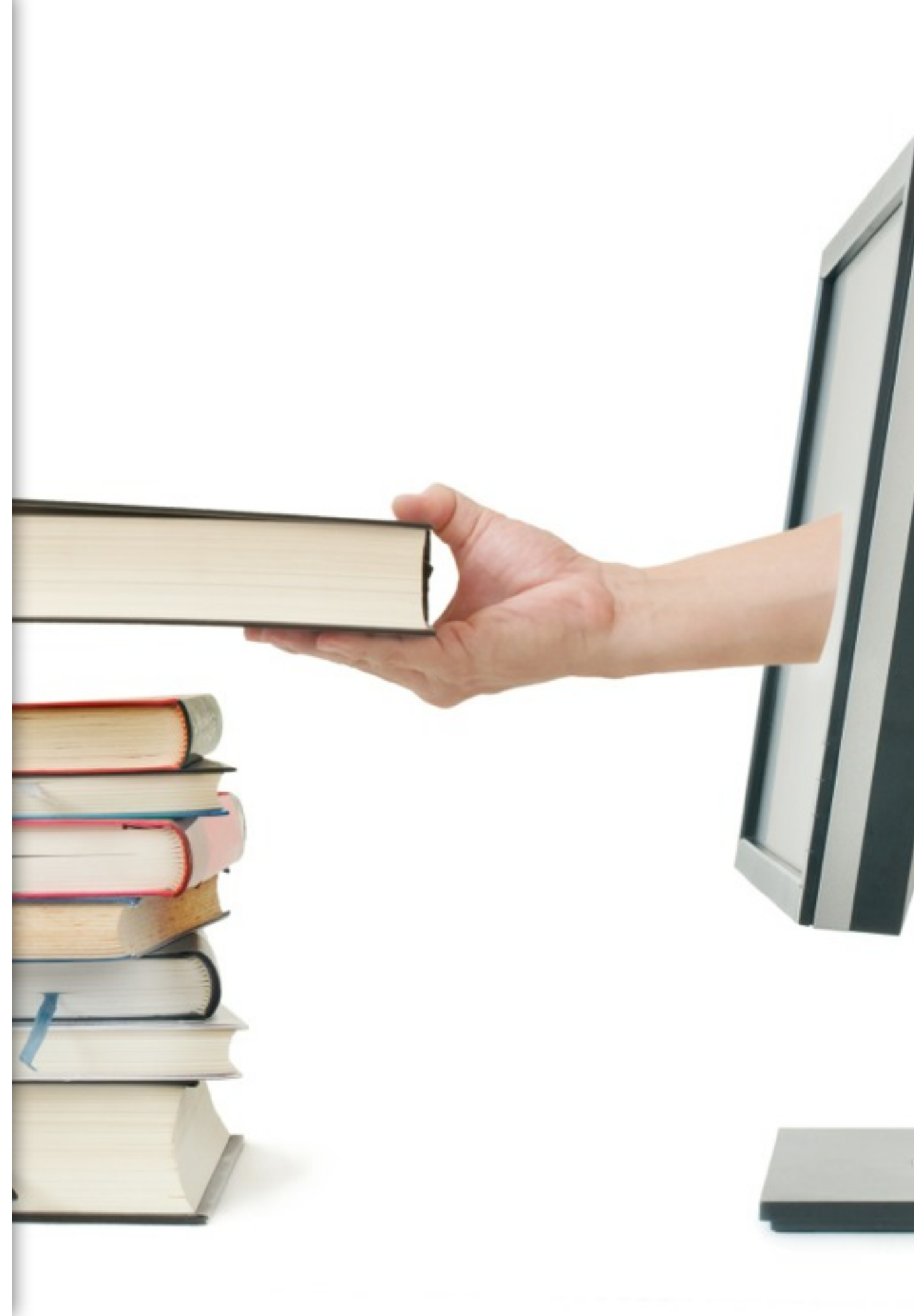


## CHAPTER 6

# Knowledge Maturing

Andreas P. Schmidt,  
Karlsruhe University of Applied Sciences, Germany

MATURE makes use of bottom up activities in social media and explores how to align these activities towards organizational goals. At the core of MATURE is the knowledge maturing process as an integrated perspective on knowledge development in organization that highlights the varying characteristics of knowledge and learning, and how they interrelate. This perspective redefines enterprise systems in the areas of competence management, business process management, or content management and promotes a learning rich workplace.



They need to be more open, participatory, and allow for continuous evolution by the users of these systems. But this also requires transformation of culture and mindsets to realise its potential. MATURE has piloted three solutions in the areas of competence management, business process management, and content management to explore their usage as part of everyday practice.

## 1 Introduction

The agility of organisations has become the critical success factor for competitiveness in a world characterised by an accelerating rate of change. Agility requires that companies and their employees together and mutually dependently learn and develop their competencies efficiently in order to improve productivity of knowledge work. Organisations have increasingly recognised the importance of knowledge and its development. But their success has been limited. They have introduced knowledge, learning and competence management systems. But their approaches to systematically supporting learning have largely failed to live up to their promises [1]. They lack employee acceptance and all too often degenerate into administrative exercises. On the bright side, social media approaches have shown that individuals are willing to collaborate, are willing to share their knowledge and are willing to help others.

But how can organisations make sense of social media activities? The challenge for organisations is to create an environment that makes use of these individual activities and that aligns them to a shared organisational objective. Existing knowledge and competence management models such as [2] or [3] do not sufficiently explain the link between bottom-up and top-down activities. And the supporting tools which use them as a blueprint do not satisfy the needs as they do not acknowledge the manifold forms of learning in organisations.

*Movie 6.1 Prof. Dr. Andreas P. Schmidt,  
Karlsruhe University of Applied Sciences*



MATURE has investigated knowledge development processes within and across organisations both from an empirical and a design perspective [9]. This has resulted in a model landscape of knowledge maturing, i.e., the development of knowledge on a collective level. This has identified phases, activities, motivational factors, and indicators for knowledge maturing. They formed the basis for designing a family of tools that redefine enterprise systems from a social media perspective, particularly competence management, content management, and process management, and integrate learning opportunities into them. Using an empirically grounded workplace learning analytics approach, the effects of these tools were evaluated as part of everyday work practice for an extended period of time.



## 2 MATURE Innovation

At the core of MATURE is the knowledge maturing process as an integrated perspective. It follows the development of knowledge from an (immature) initial idea vague thought through the discussion in communities and the transformation for wider distribution, via piloting up to institutionalisation and standardisation. It consists of interconnected individual learning activities where the output of the first is input to the next.

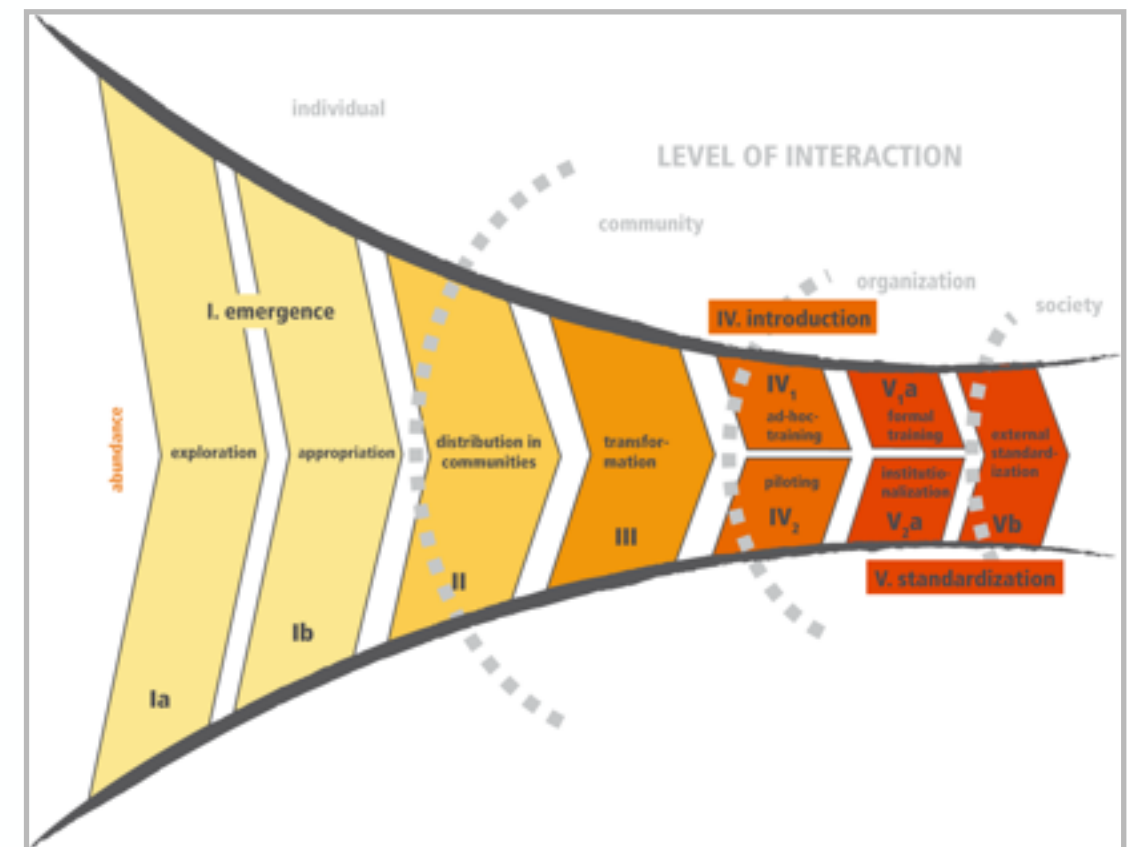
### 2.1 Knowledge maturing model landscape

A key observation is that along this process the characteristics of knowledge and corresponding learning activities change significantly and that alongside the process, characteristic barriers need to be overcome. This influences the requirements for learning support, and shows the links (“transitions”) between different learning activities. MATURE has conceptualised this into a phase model that is shown in [Figure 6.1](#), which consists of the following phases [4]

- *I. Emergence.* Individuals create personal knowledge by pursuing their interests. Knowledge is subjective, deeply embedded in the originator’s context. It consists of two sub phases: a) Exploration and b) Appropriation.
- *II. Distribution in communities.* The phase includes discussing the new knowledge, negotiating its meaning and impact, co-developing knowledge, convincing others and agreeing plus committing to the knowledge as collective. A common terminology is developed and shared among community members.
- *III. Transformation.* Knowledge is restructured and put into a form appropriate for moving it across the community’s boundaries. Structured documents are created in which knowledge is de-subjectified.

- *IV. Introduction.* We found two primary interpretations of introduction, i.e. (1) an instructional setting (“ad-hoc training”) in which didactical aspects are added and (2) an experimental setting (“piloting”) in which a limited scale trial (preceding a larger scale roll-out) is the vehicle for further knowledge development.
- *V. Standardisation.* The knowledge is further solidified and formally established in the organisation to be used in repeatable formal trainings, work practices, processes, products or services. As in phase IV, we distinguish (1) an instructional setting with standardised training activities (“formal training”), and an experimental setting turning pilots into standard organisational infrastructure, processes and practices (“institutionalisation”). This leads to the ultimate maturity sub-phase Vb (external standardisation).

Figure 6.1 Knowledge Maturing Phase Model [4].



This model provides a landscape of the manifold forms of learning in organisations. It allows for locating human resource development through trainings (phases IV and V), document-centric knowledge management (phases III and IV), idea management (phases I-IV) or social media (phases II and III). The model has proven useful and it is an instrument for analysing connections and barriers in between them.

From this nucleus, a knowledge maturing model landscape has been developed in intertwined empirical research activities (ethnographically informed, interview-based, and case study driven) and participatory design activities. This has resulted in:

- *Knowledge Maturing Activities* [5], identifying key employee activities that contribute to knowledge maturing which have different characteristics based on the maturing phase.
- *Knowledge Maturing Indicators*, making knowledge maturing traceable, either based on interactions with the system or direct quality measures, some of which can be automatically calculated by Maturing Services that form the basis for learning analytics at the workplace.
- *Guidance Activities*, describing possible interventions from various perspectives to promote knowledge maturing.
- *Motivational Aspects and Barriers* [8], pointing towards possible measures on the individual, collective, and organizational level.

## 2.2 Knowledge Maturing Tool Support

This redefines many company processes and tools. A closer investigation of why enterprise systems for supporting collaboration, competence development, or process management fail to live up to their promises, reveals that such systems tend to ‘over-formalise’, put too much emphasis on access control, or a-priori quality control. All of



these are symptoms for a misalignment of the underlying artefacts with the actual (collective) knowledge about real-world aspects. In this respect, MATURE has particularly focused on the barriers in early phases that hinder wider participation.

One area is *competence management* and the knowledge about others' expertise. Competence management systems are based on competence catalogues that are created by expert groups in long and expensive processes. However, these competence catalogues are only rarely updated and thus do not contain up-to-date emerging competencies. Furthermore, competence scales often suggest an accuracy for competence profiles that does not reflect the ambiguity of the underlying competence notions. From a knowledge maturing perspective, these systems do not take into account the dynamic nature of competency notions as cultural constructs. MATURE has used a lightweight people tagging approach [6] where individuals can assign topic tags to each other. And by giving employees the opportunity to collaboratively develop a competence catalog, it bridges the early, highly informal phases with the later phases that

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require formal definitions. And it allows for topics appearing much earlier than before.

Another area is *business process management*. Business process support systems are based on highly formalised business process models. A common problem is that these process models are not appropriate for the situations encountered in daily work practice so that employees do not comply, create shortcuts or similar. In most cases, the issue is not that the process model is wrong. In the light of the knowledge maturing model, the underlying problem is that the actual knowledge is not mature enough to be specified in a process model. As a solution, a task management based tool was developed [7]. It starts from the assumption that the development of process knowledge does not start with formal process models, but with individual and collaborative task management. By detecting and sharing patterns and adding experiences to them, it evolves into reusable guidelines that could eventually turn into prescriptive processes.

*Document-centric systems* have been viewed as the key instrument to knowledge management in the past generation of knowledge management systems. While documents can be useful for distributing knowledge to a large audience, they are only an efficient approach if the knowledge represented in them has the same maturity. It is comparably much less useful to document ideas that are too heavily contextualised. Also we need different types of functionalities for different phases: the earlier phases need easy collaboration, while the latter phases are more about quality control. A one- size-fits-all approach is not possible, although it would be desirable to have a single system, also to ensure continuity. Here a flexible widget-based environment with low- barrier support for various knowledge maturing activities has been developed [10].

### 3 A possible future from the perspective of MATURE

MATURE has successfully trialled new solutions that create more agile and dynamic environments. Key to these solutions was designing learning and knowledge development into enterprise systems: the development of a collective knowledge how to describe individuals' expertise, the development of knowledge how to execute and coordinate activities (process knowledge), and the development of artefacts representing knowledge. This forms part of a vision of creating a learning rich workplace, which delivers companies the advantage that topics disseminate much quicker into the organisation, the creation of documents, taxonomies, or process models is much more agile. This increases the company's capacities to innovate.

But it is also obvious that the knowledge maturing perspective challenges traditional company approaches and cultures. Systems that are centred around administrating learning need to turn into systems facilitating learning. Instead of control, their internal models (such as catalogs, or process models) needs to be much more open to change by the individuals using the system. And these systems need to connect within a Learning and Maturing Environment.

The increasing adoption of enterprise 2.0 approaches is a promising sign that companies realise the importance of participation, but from a knowledge perspective, they still lack a conceptual and technical framework for making sense of social media in the long run. This is delivered by MATURE. A crucial part is formed by Knowledge Maturing Indicators which pave the way for productive learning analytics at the workplace. A Knowledge Maturing Scorecard [11] integrates it into management processes. While there are a lot of technical issues in moving to a more dynamic and interconnected perspective, it is not only about technology. As the empirical studies have shown a change of the mindset on all levels of an organisation is crucial.



## 4 Conclusion

MATURE has developed the Knowledge Maturing Model Landscape to describe how knowledge development on a collective level takes place. The Knowledge Maturing perspective views the various learning activities within an organisation as interconnected. It helps to move away from isolated approaches to learning. It shows that it is not only about formal learning or informal learning, it is about viewing these two as interconnected, bridging departments and responsibilities. Through transforming enterprise systems, across which currently learning is scattered, we can create a learning rich workplace that fosters knowledge maturing activities.

This addresses key challenges in the research field of technology enhanced learning. It gives a conceptually sound and practically relevant model and tool vision for bridging informal and formal contexts to create a unified learning landscape. Its learning rich workplace contributes to Personalized Learning Environments and promotes Interest-driven life-long learning. Through its knowledge maturing indicator framework, it also represents a landmark in learning analytics, for Making use and sense of data for improving teaching and learning.

Key to success of the knowledge maturing approach is that technology introduction is complemented by and synchronised with a transformation of mindset and culture in an organisation. This includes many aspects, including the understanding of the role of IT in an organization, and leadership. As a catalyst for change, MATURE has initiated a Knowledge Maturing Consulting Network (<http://knowledge-maturing.com>) to realise its vision of a learning rich workplace beyond the project's lifetime.

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## CHAPTER 7

# Responsive Open Learning Environments

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Personal Learning Environments (PLEs) hold the potential to address the needs of formal and informal learners for multi-sourced content and easily customisable learning environments. This chapter presents an overview of the European project ROLE (Responsive Open Learning Environments), which specialises in the development and evaluation of learning environments that can be personalised by individual learners according to their particular needs, thus enabling them to become self-regulated learners.





# 1 Introduction

An ageing society and a flexible economy need lifelong learning more than ever, otherwise risking that school kids today know more than employees trained half a decade ago. Lifelong learning requires learners to actively control their learning activities while addressing the requirements imposed on them in their respective life contexts. Life context here can be the school, the university, the workplace, the hobby, etc. This leads to a shift from a centralised institutional teaching approach to a more learner-centred decentralised learning approach [18]. In order to support this shift, learning environments must change to more responsive and open, allowing breakthrough levels of personalisation.

In this paper, we will reflect on the approach of the European project **ROLE** (Responsive Open Learning Environments). ROLE enables learners to compile their personal learning environments according to their particular needs and goals. Consequently, the ROLE approach supports self-regulated learning while taking into account the requirements from the roles of the learners and the teachers.

The remainder of this paper is structured as follows: First, recent advances in personalised and self-regulated learning are introduced. Based on these advances, the key innovations of the ROLE project are presented, with emphasis on evaluating these innovations in the project's test-beds. Finally, the paper is concluded with a summary of the key ROLE contributions to technology-enhanced learning.

## 2 Personalised and self-regulated learning

The Learning Management System (LMS) has dominated technology-enhanced learning for several years. It has been widely used by academic institutions for delivering their distance learning programmes, as well as for supporting their students outside the

*Movie 7.1 Dr. Alexander Mikroyannidis,  
The Open University, UK*



classroom. The LMS has been a powerful tool in the hands of educators, enabling them to complement face-to-face teaching in the classroom with remote work by individual students, as well as groups of them [1,3,16,17].

However, the advent of Web 2.0 has altered the landscape in technology-enhanced learning. Learners nowadays have access to a variety of learning tools and services on the cloud. These tools and services are usually provided by different vendors and in many cases are open and free. However, augmenting and configuring these diverse and distributed tools and services in order to address the needs and preferences of individual learners is a significant challenge for modern online learning environments.

This ongoing transition from the traditional approach of the LMS towards Web 2.0-based learning solutions bears significant benefits for learners. It puts emphasis to their needs and preferences, providing them with a wider choice of learning resources to choose from.

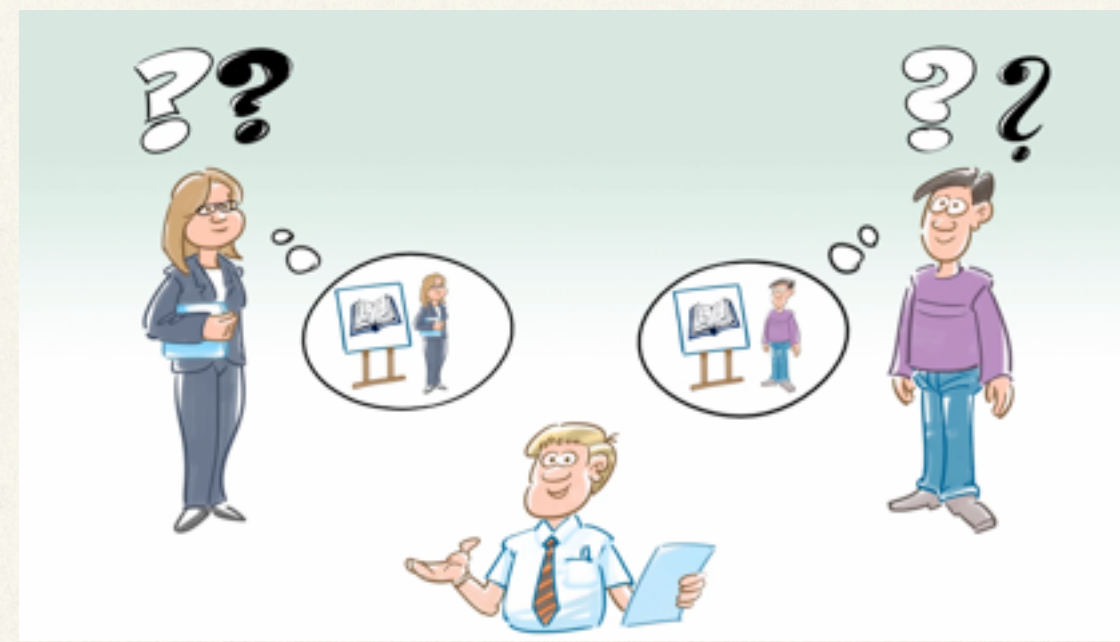
Learners usually switch learning contexts continuously, adapting to the respective needs automatically. The LMS is not able to provide learners with the required flexibility. Furthermore, the LMS is a closed system that does not allow the learner to take her achievements with her when leaving the LMS-providing learning organisation, e.g. the university.

The Personal Learning Environment (PLE) is a facility for an individual to access, aggregate, manipulate and share digital artefacts of their ongoing learning experiences. The PLE follows a learner-centric approach, allowing the use of lightweight services and tools that belong to and are controlled by individual learners. Rather than integrating different services into a centralised system, the PLE provides learners with a variety of services and hands over control to them to select and use these services the way they deem fit [4, 19].

The emergence of the PLE has greatly facilitated the use and sharing of open and reusable learning resources online. Learners can access, download, remix, and republish a wide variety of learning materials through open services provided on the cloud. Open Educational Resources (OER) can be described as “teaching, learning and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use or repurposing by others depending on which Creative Commons license is used” [2].

Self-regulated learning (SRL) comprises an essential aspect of the PLE, as it enables learners to become “meta-cognitively, motivationally, and behaviourally active participants in their own learning process” [20]. Although the psycho-pedagogical theories around SRL predate very much the advent of the PLE, SRL is a core characteristic of the latter. SRL is enabled within the PLE through the assembly of independent resources in a way that fulfils a specific learning goal. By following this paradigm, the PLE allows learners to

*Movie 7.2 Self-regulated learning principles.*



regulate their own learning, thus greatly enhancing their learning outcomes [7, 14].

### 3 Key ROLE innovations

The notion of lifelong learning as discussed today formulates a number of requirements on the technological basis and learning and business processes associated. As our target group ranges from all possible domains and roles, e.g. learners, teachers, companies, employer, employees, learning organisations, etc., opportunities arise that will support the current shift in education towards more self-regulated learners [15] in scenarios, where the teacher role shifts more towards a mentoring role: the centralised institutional teaching approach shifts to a more learner-centred decentralised learning approach [18].

The ROLE project provides solutions to this set of complex challenges by advancing the state of the art in the technology and methodology it uses. The following sections outline the ROLE approach in technology and methodology.

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### 3.1 Technology: Interoperable infrastructure enables PLE composition

ROLE has provided an infrastructure that enables learners to create their own personal learning environments, while maintaining a close link to the rules and restrictions of the education-providing organisation [5, 8]. In essence, the idea is to loosen the control on the learner while maintaining the ability to certify learner achievements. For example, the learner chooses the required learning tools and contents from a wide selection and compiles them into her individual PLE. At the same time, the education provider can control which tools and contents can be chosen by the learner.

ROLE tools and content within the PLE are able to communicate with each other in order to enable tools and contents to react to each other based on the user interaction. Finally, rather than replacing LMS, the ROLE approach allows the successful augmentation of existing learning environments. This way, the costs for introducing the ROLE approach to existing learning environments is significantly reduced, which fosters its uptake.

### 3.2 Methodology: Self-regulation as the key learning paradigm

Learners today are not aware of the advanced learning paradigm of SRL. In most cases, the basic components of SRL, that is cognition, meta-cognition, motivation, affects, and volition [6] are used by learners intuitively without understanding the conceptual background. Apart from supporting SRL in PLE creation and use through respective recommenders, collaboration tools and best practice sharing, ROLE raises awareness through a number of dedicated learning resources. These range from [short videos explaining the SRL principles](#) (see [Movie 7.2](#)), to bespoke [online courses about SRL](#) that help teachers and students understand the mechanics and benefits behind SRL.

## 4 Evaluating the ROLE technology and methodology

The ROLE innovations in technology and methodology have been proven successful in a number of large test beds that run continuously throughout the lifetime of the project and beyond [11,12,13]. The ROLE test-beds cover a wide variety of rich contexts inside and outside Europe, in which there is potential for significant impacts of both personalised and self-regulated learning. Each test-bed concentrates on researching a large sample of representative individuals; this has enabled ROLE as a whole to collect experiences covering a large variety of learning contexts and requirements. [Figure 7.1](#) illustrates the five original ROLE test-beds, each investigating a transition in learning. Additional test-beds have also been setup either by ROLE partners in their respective institutions or by researchers and educators external to the project [12, 13].

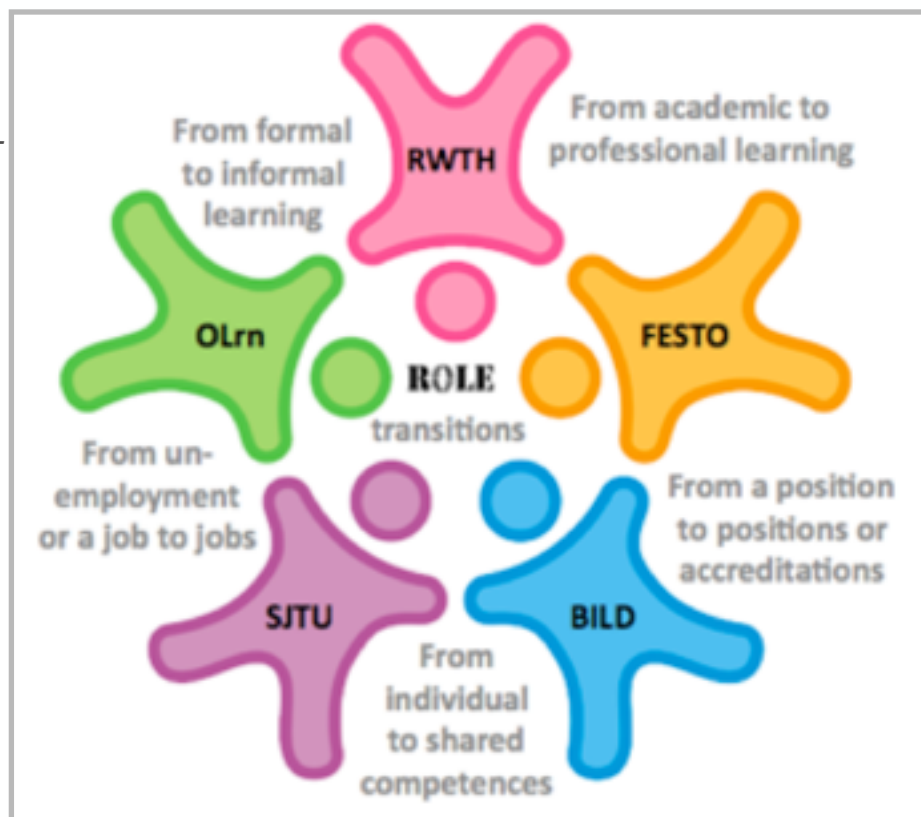
The Open University in the UK comprises one of these test-beds, concerning the learner's potential transition from formal to informal learning [9, 10]. The test-bed in question is [OpenLearn](#), an OER repository offered by the Open University. OpenLearn users are primarily informal learners, who want to find and study OER either individually or in collaboration with others. The ROLE intervention in the OpenLearn test-bed has been about improving the informal learning experience in a number of ways. First of all, by enabling individuals to build and personalise their learning environment, thus gaining more control over the use and manipulation of study materials. Additionally, the adoption of certain ROLE tools inside OpenLearn is offering further value to learners through fostering learning communities. This presents an opportunity to individual informal learners to be part of a shared learning experience instead of a lone study.



Other ROLE test-beds focus on formal education, and specifically Higher Education. These test-beds explore the usefulness of the PLE for facilitating and complementing the learning that happens inside the classroom. Learning in the workplace has also been targeted by test-beds that explore the challenges and opportunities associated with self-regulated learning in the workplace and the sharing of best practices among employees.

Evaluation results from the test-beds indicate the best suitability of the ROLE approach for self-regulated learners while providing significant improvements even in traditional learning scenarios where ROLE tools are used for homework-like assignments. Additionally, the successful evaluation of the ROLE approach has led partners to include it in their commercial products and consulting practices.

*Figure 7.1 The original ROLE test-beds and the associated learning transitions.*



## 5 Conclusion

In summary, the vision of the ROLE project has been to provide the necessary infrastructure and processes for any learner across the world to assemble their own PLE, while enabling the education provider to exercise the necessary control to facilitate the certification of the learning achievements. From a technical point of view, the approach taken by ROLE enables the flexible composition of technologies by the end user in the sense of mashing-up learning tools and technologies at the 'clients' side.

Today's rapidly changing education and employment conditions demand a lifelong learner who is flexible, motivated and in control of his or her learning. The ROLE initiative has significantly advanced the state of the art in technology-enhanced learning, by providing lifelong learners with the tools and support they need for personalising their learning and developing a wide range of self-regulated learning skills.

## Acknowledgment

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## CHAPTER 8

# Rapid Competence Development

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Employers report a shortfall in some competences deemed essential to have in the repertoire, such as ‘capacity to analyse and solve problems’ and ‘ability to develop new and innovative ideas, directions, opportunities or improvements’. The analytical learning and competence building approaches that have proven efficient when dealing with simple and complicated problems prove inefficient when confronted with complex problems.



Today, the main route to reducing Time-To-Competence is a bespoke face-to-face or blended course, which tends to be resource-intensive. What are needed are methods to effectively and economically address dynamic competence development rapidly. TARGET achieves a step by integrating five significant developments needed in combination for sustainable agility: Threshold Concepts, Knowledge Ecology, Cognitive Load Theory, Learning Communities and Experience Management (using Serious Games). The solution explored in TARGET takes into account changes in the external environment to allow users to become aware about those changes and modify their learning plans to suit. This delivers added value on the social, economic and academic dimension, compared to today's mainstream learning environments and tools. The TARGET research results have led to the incorporation of the HighSkillz start-up, with scheduled release of the commercial platform in 2013.

## 1 Introduction

In today's global market, human capital is a recognized strategic asset in companies, which require corporate processes to secure and maintain the best talent within the organization. Learning and training play a foundational role in talent management, but establishing effective learning strategies across enterprises remains a costly challenge without measurable return.

As evidenced in the study by Nair et al .[1] employers report a shortfall in some competences deemed essential for a graduate engineer to have in their repertoire, such as 'capacity to analyse and solve problems' and 'ability to develop new and innovative ideas, directions, opportunities or improvements'. In fact, most modern problems are more frequently complex rather than complicated. Complex problems are messier and more ambiguous in nature; they are more connected to other and often very different problems; more likely to react in unpredictable non-linear ways; and more likely to produce unintended consequences. Most organizations have been designed to deal with a

*Movie 8.1 Dr. Manuel Oliveira, SINTEF*



complicated rather than a complex world. Hierarchical and silo structures are perfectly designed to break problems down into more manageable fragments. They are not, however, so effective in handling high levels of complexity. For this reason many institutions and companies are now struggling to adapt to a more complex world. When problems become complex, the clear pattern between cause and effect disappears, with understanding taking place in retrospect. Instructive patterns, however, can emerge if the leader conducts experiments that are safe to fail. That is why, instead of attempting to impose a course of action, it is necessary to probe first, then sense, and then respond.

The analytical learning and competence building approach that have proven efficient when dealing with simple and complicated problems proves inefficient when confronted with complex problems. In 1984, David Kolb published his book title "Experimental Learning" [2]. His claim is that we are learning by cyclic patterns of four types of activities: Concrete experience, reflective observation, abstract

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conceptualization, and active experimentation. According to Kolb it does not matter where we start - the important requirement for real learning is that one goes through the full cycle. Though Kolb's work is aiming at the individual level there are several contributions supporting that a similar pattern is valid at the organizational level.

Dorothy Leonard argues that: "The primary activities spawning organizational learning are experimentation and prototyping" [3] and Argyris and Schön have introduced the notion of single-loop and double-loop learning, which includes active experimentation [4].

Donald Schön has been studying how professionals are working very differently from novices [5]. His point is that when people have reached a certain level of professionalism it will change their working style and become "reflecting practitioners". The reflective practitioner is in a constant process of thinking, reflecting, acting, and building experience – very much in line with the learning process as described by Kolb. This process is efficient for the professional person but due to the amount of tacit knowledge it is often difficult to articulate and share the results with others [6].

Today, the main route to reducing Time-To-Competence (TTC) is a bespoke (handcrafted) face-to-face or blended course, which tends to be resource-intensive (expensive to create and deliver). What are needed are methods and tools to effectively and economically address dynamic competence development rapidly, with flexible learning contexts of varying complexity and longevity.

One challenge is that each learner is a unique individual, with different cognitive abilities, emotional intelligence, personality, knowledge, and experience. Thus, it is not feasible to develop a single solution tailored to all learners, but rather it is necessary to support mass-individualization. The problems are exacerbated by the need to retain the capacity to handle unpredicted events, meaning that at least some of the learners/managers in an organisation need to attain novel ways of understanding and the ability to think with different perspectives.

Aldrich [7] draws an interesting parallel of e-learning industry with the fast-food industry, where the focus is in reducing costs, increasing efficiency, and minimizing the time spent by a customer in eating.

Unfortunately, in maximizing the process efficiency of fast-food, the nutritious and health value of a meal has been neglected and similar claims are made concerning e-learning, where the focus is on maximizing the efficiency of delivery of content, but not necessarily achieving the TTC. As poignantly evidenced in the global economic crisis, there is a lack of agility in processing new knowledge and acquiring new competences to address the challenges and exploit emerging opportunities.

However, mainstream corporate e-learning has generally failed to deliver competence development in areas that are commercially valuable and can add significantly to the competitiveness, agility or resiliency of an organization, such as competences associated with the fast commercialization of R&D results or with keeping a complex IT project focused, on time and within budget.

Even in less-demanding areas of competence development such as basic IT skills, there are very few cases demonstrating a significant return in terms of flexible capacity development, investment in learning time and effective transformation; instead, most cases turn out to be expensive and inadequate solutions.

To compound the challenge of fast personalized delivery, an emerging challenge is the advent of the "digital natives" who due to their familiarity with multiple technological stimuli and social interactivity, have become more demanding on how the facilitation of learning should be carried out and e-learning needs to take account of the enhanced abilities of the "digital natives", which can give them a competitive edge in fast-changing market situations such as arise in economic downturns.

The main aim of TARGET is to research, analyse and develop a new genre of responsive Technology Enhanced Learning (TEL) environment



that supports rapid competence development of individuals. Additionally, TARGET can respond dynamically to the ever-changing business needs of an organization and the evolving personal goals of individuals

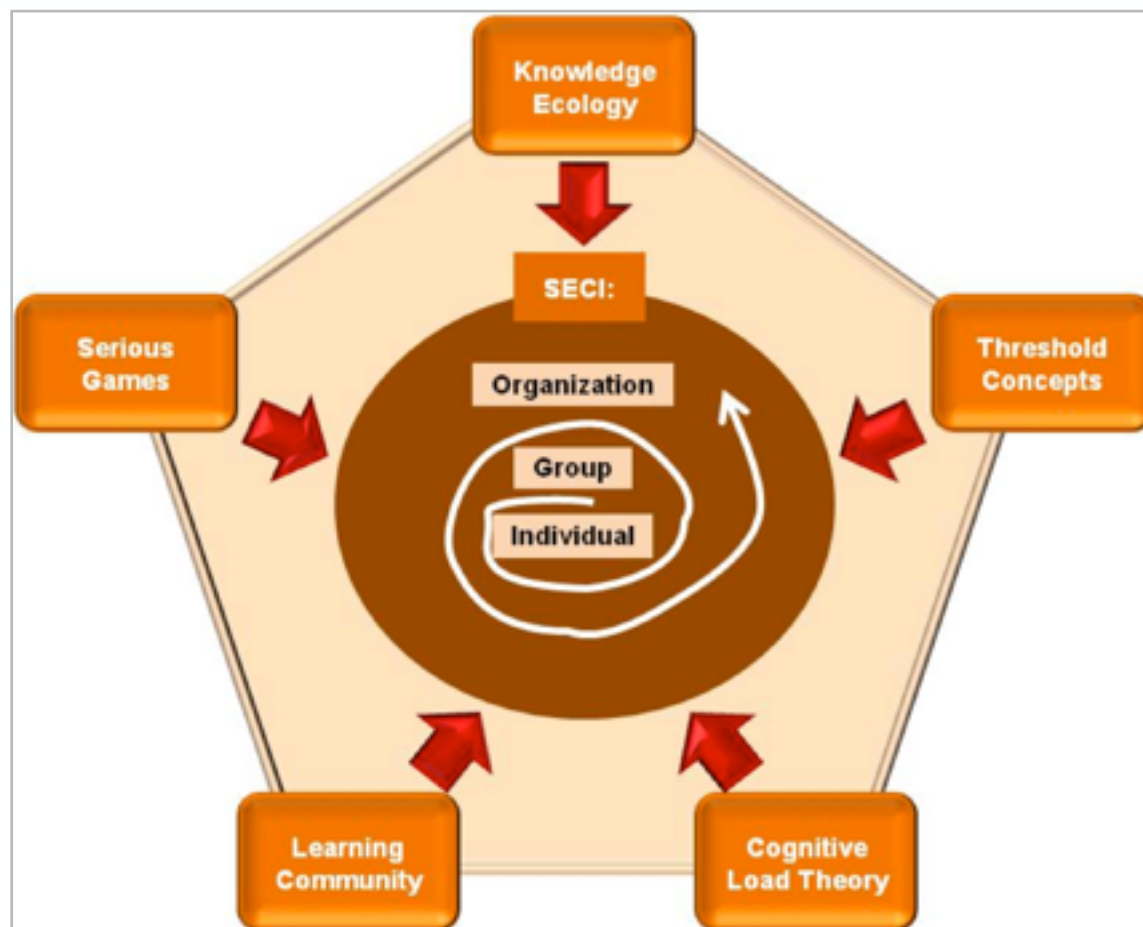
## 2 The TARGET Innovation

TARGET [8] achieves a step change in what can be done through TEL, by integrating five significant developments (Figure 8.1), needed in combination for sustainable agility and brought together here for the first time in TEL: Threshold Concepts [9], Knowledge Ecology, Cognitive Load Theory, Learning Communities and Experience Management (using Serious Games). The combination of all five together supports the TARGET learning process at individual, group and organization level.

The TARGET learning process, schematically represented in Figure 8.2, has four distinct phases:

- **Plan.** The TARGET Learning Process begins with the learners deciding if they wish to do goal-oriented learning or self-directed learning. In the case of goal-oriented learning, the learners create a learning plan with desired learning outcomes by defining their current competence and target competence profiles. Based on the resulting gap, the platform generates custom stories tailored to the particular needs of the individual learner. Each story captures a situated context where the learner is challenged in using a set of competences. The process of creating the learning plan is governed and shaped by a learning strategy that is chosen by the learner. In the case of self-directed learning, the learner builds their learning plan from the TARGET knowledge assets made publically available by others within the community (this may be other learners or content providers with crafted stories).
- **Experience.** This phase involves the learner selecting a role within a Story, resulting in an experience. Whilst engaged with the Story, the system provides an environment where the learner engages with other characters (controlled by pedagogical agents) and the environment, enacting their decisions. These decisions will have an

Figure 8.1 TARGET Integrative Framework [10]



impact that will affect and change the situated context of the Story. Whilst experiencing a Story, the system will monitor the actions of the learner, taking into account the desired learning outcomes, thus making changes to the Story if necessary. As examples, these changes may be modifying the personality of a Non-Player Character to be more confrontational or delaying tasks within a project.

- *Individual Reflection.* This phase initiates with the termination of the learner's experience of the Story. The learner is then presented with the final assessment of their competence during the experience in the form of a timeline. The ability of looking back on their decisions by reviewing how the story unfolded whilst cross-referencing the assessment of their competence at each point in time, allows the learner to evaluate their performance leading to reflection from an individual perspective.
- *Social Reflection.* Evidence demonstrates that externalization of tacit knowledge and learning is useful in making that knowledge active (in the sense of a learner being able to transfer knowledge to a new context, such as day-to-day challenges they face as new hires in an organization). According to the SECI framework [11], the learning community plays an important role in the learning process in externalization of knowledge through socialization. Furthermore, the social aspects address the need of an ability to deal with flux and instability, and to thrive in situations of flux. Consequently, in TARGET, social learning is here seen as eco-system with constant interplay between the learner and their context. Through the engagement with others and reflection, the learner will internalize their experience, thus enabling them to enhance their repertoire.

Figure 8.2 Overview of the TARGET learning process and the supporting platform



### 3 The TARGET Impact

Becoming and staying globally competitive is an imperative for Europe. TARGET addresses a key point: how to lead in the knowledge economy in an affordable and sustainable way. The solution explored in TARGET takes into account of changes in the external environment, in ways that allow users to become aware about those changes, and modify their learning plans to suit. This gives a new slant to the idea of "just-in-time-learning", giving organizations and individuals earlier warning of what challenges they will face (e.g. when new industries

emerge) and what knowledge and skills they will need. We anticipate that TARGET enables a dramatic rise in EU competitiveness.

TARGET offers a way for private-sector and public-sector organisations (a) to move to shorter learning cycles and (b) to make faster switches in learning contexts. Both (a) and (b) are essential for agile approaches to incremental and radical innovation. As a result of using TARGET for capacity building in innovation and project management, organisations will find it easier to anticipate changes in their external environment and alter direction if needed. They will also find it easier to adopt new knowledge and processes, and to transfer and share knowledge (e.g. in developing joint ventures or joint product development). The impact on competitiveness will be large: Europe's organisations will be better able to deploy their knowledge base to handle changes in: customer expectations (e.g. as to the value they get); cost-base (competition from low-wage regions); constraints (e.g. energy efficiency goals); and paradigms (e.g. 'carbon footprint' is now part of the business vocabulary).

TARGET's form of responsive TEL environment delivers added value on the social, economic and academic dimension, compared to today's mainstream learning environments and tools, which do not effectively address dynamic competence development in a short time with flexible learning contexts of varying complexity and longevity. In addition, TARGET makes it easier for employers to provide training that treats each learner as a unique individual, with different cognitive abilities, emotive intelligence, personality, knowledge and experience. The approach taken by TARGET is not to develop a single solution tailored to all learners, but rather to support mass-individualization, helping learners to attain novel ways of understanding and the ability to think with different perspectives. Additionally, TARGET raises the effectiveness of organizational learning, since it enables enterprises to aggregate their tacit knowledge in ways that allow new employees to take advantage of it. This attention to succession planning via knowledge codification will make enterprises less vulnerable to high





personnel turnover and will help to enable mobility at an industrial level in Europe

TARGET will have a significant influence, growing over the long term, on the nature of human work and collaboration in a knowledge based and ambient collaborative environment. In particular it focuses on exploring a new type of collaboration environment that is human centred and at the same time integrated into the business processes of networked enterprises. Personalization and adaptation have multiple layers, which include languages, locations, time scales, cultural backgrounds, personal domains, personal and team tasks and administrative work procedures. We believe that TARGET boosts development of new generation collaborative environments and services, which would be capable to support the knowledge workers in bridging the gap between their individual needs and the organizational structures. This will create new workflows to be integrated into the stakeholder environments, be it social, work or home.

TARGET supports the dialog between science and society by raising and keeping the awareness of interested stakeholders and the society in general about the project and project results. TARGET also contributes to the proper use of scientific results and innovation for the general benefit of the society by providing sound solutions to the problem of allowing continuous training and evaluation of business scenarios. This leads to better development of products and associated operations with improved quality characteristics in terms of safety, comfort, facility of use, less use of resources, and respect for the environment.

## 4 Conclusion

The economic recession maintains a strong grip on the world economies, and the European Union is faced with the challenge of increasing its resilience of European Industry towards the global competitiveness, the ever-increasing complexity and the rate of change. Europe has recognized [12] the strategic importance of building up human talent [13], through competence development and life-long learning, to foster the economic recovery through the excellence of its education and training to best equip people with the necessary knowledge, skills and competences throughout the lifetime of an individual, from early childhood to adulthood. TARGET changes the approach to reducing time to competence by providing personalized and adaptive learning.

As a result of the strong exploitation potential, the TARGET research results have lead to the incorporation of the HighSkillz start-up, with scheduled release of the commercial platform in 2013. The TARGET prototype limitations have been addressed in the new HighSkillz platform, providing a cloud service accessible across any device: mobile, tablet and laptop. A captured screenshot of the experience is displayed in [Figure 8.3](#).



*Figure 8.3* Captured screenshot of the HighSkillz platform

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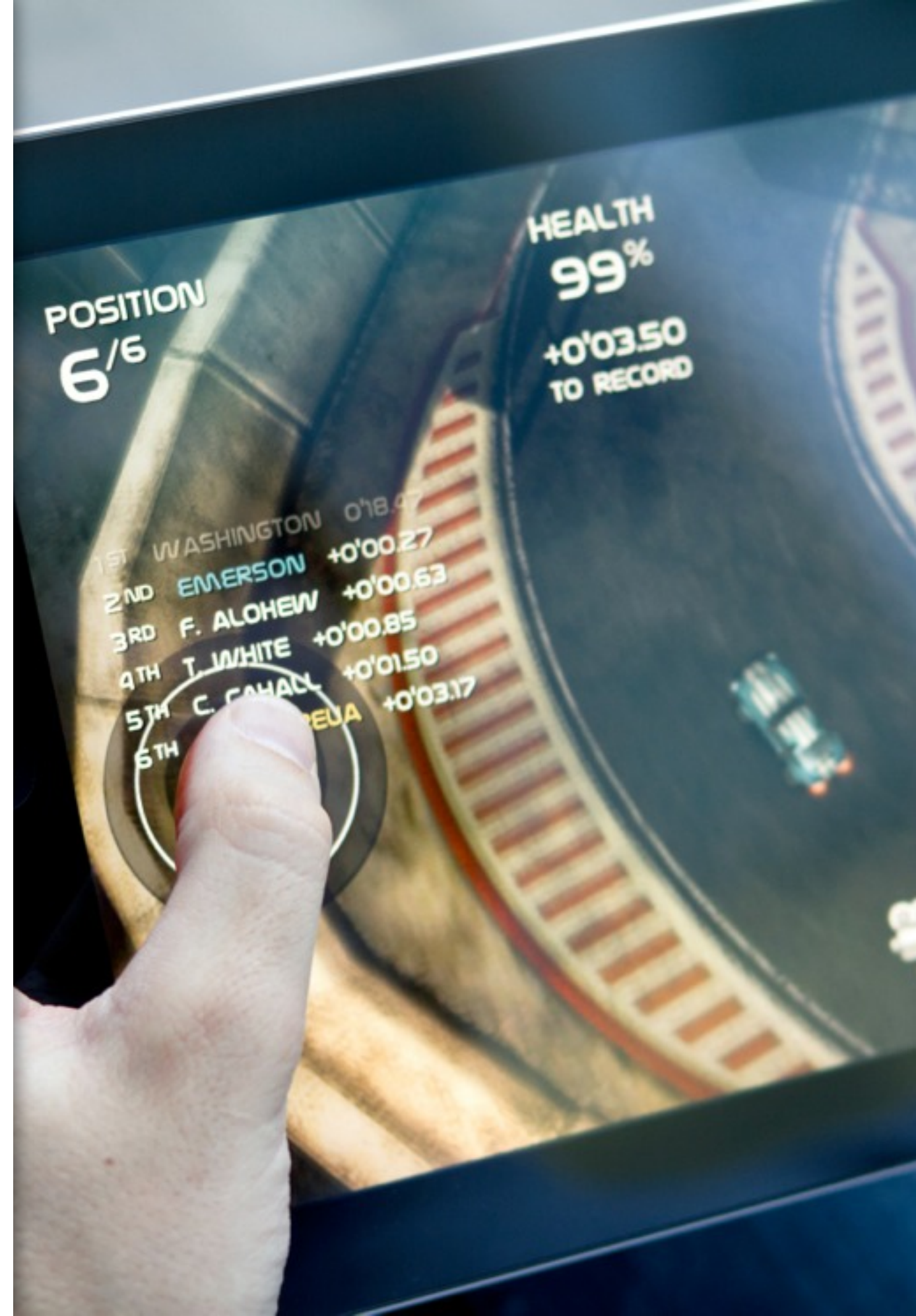
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# Serious Games

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Serious Games represent a very promising tool for instruction and learning as they exploit the appealing technologies of video-games to bring educational contents and applications to a potential wide audience.

However, appropriate game design rules, tools and methodologies, proper interaction and feedback modalities and effective stealth assessment methods needs to be studied and developed in order to meet requirements and expectations.





This implies a long research road (in diverse fields such as Artificial Intelligence, pedagogy, game design, computer graphics, modelling and simulation, etc.), that the Serious Games Society (SGS) is committed to indicate, explore and shape.

## 1 Introduction

Some aspects of education – notably, learning and training – seem particularly suited to computer-based support. In this regard, some game technologies seem effective and promising, also because they address several e-learning problems such as high dropout rates due to frustration and the lack of motivation to continue studying [14, 20].

The potential of Serious games (SGs) is relevant, because a large and growing population is familiar with playing games, that can present users with compelling challenges set in realistic environments, favouring situated cognition and highly stimulating their information processing capabilities and capturing their concentration span for long duration [14, 22]. Games provide immediate feedback that may be efficient for procedural learning. Virtual environments and simulations are effective over non-computer methods, as they allow for high levels of fidelity and an immersive experience [2]. This is expected to create new tools for instruction, thus also opening significant market opportunities. As a matter of fact, data clearly speak about a favourable trend for Serious Games. IDATE [11] estimates the current global market of Serious Games at 2.35bn €, with steady growth and huge potential.

In general, most authors agree that more extensive tests need to be performed in order to provide valid and reliable evidence for effectiveness of Serious Games as educational tools (e.g. [19, 10]). Providing evidence that employment of Serious Games leads to improved learning in an efficient and attractive way is necessary in order for Serious Games to become a proper and useful educational

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tool. Furthermore, there is a growing concern that there is a need for scientific and engineering methods for building games as means that provide effective learning experiences [9].

While the potentiality of Serious Games for education and training is well acknowledged, there is the need to address the challenges of the main stakeholders of the Serious Games European landscape (users, researchers, developers/industry, educators), in particular considering the fragmentation (e.g., in terms of research groups and works, of geographic distribution, of educational offer, etc.) that affects the Serious Games landscape. This has been the motivation for creating both the Games and Learning Alliance (GaLA) Network of Excellence [3] and of the Serious Games Society (SGS) [5], an international cultural association aimed at integrating and supporting research on Serious Games and disseminating knowledge, best practices and tools as a reference point at an international level.

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## 2 Gamification in learning

A recently emerged trend is about gamification, which is gaining relevance also in education. An example of this is [Quest2Learn](#), a school in New York where the entire structure of learning over the course of the unit, and year, is gamified [15]. Gamification is the process of using a game approach and game mechanics to engage users and enhance participation and performance [21]. Serious Games can be a useful component of the gamification process (e.g., units of the gamified process could be implemented through Serious Games), and the whole process itself could be gamified as a large serious game.

The Deloitte 2012 annual Technology Trends report [7] includes gamification among the five “Disruptors” technologies. By 2014, more than 70 percent of “Global 2000” organisations will have at least one “gamified” application, according to Gartner [8]. Analysts said that while the current success of gamification is largely driven by novelty and hype, gamification is positioned to become a highly significant trend over the next five years.

A recent Pew Research Center report [12] titled ‘The Future of Gamification’ (capturing Internet experts’ and other Internet users’ expectations for the future of the internet) states that Tech stakeholders and analysts generally believe the use of game mechanics, feedback loops, and rewards will become more embedded in daily life by 2020. According to Mike Liebhold, senior researcher at The Institute for the Future, the development of ‘Serious Games’ applied productively to a wide scope of human activities will accelerate simply because playing is more fun than working.

Generally speaking, there are concerns about gamification. In particular, some risks are apparent for learning. These include behaviours that may be induced on users, such as: addiction/compulsion, difficulty of distinguishing between fiction and reality, and

development of an utilitarian mentality. Other concerns are about the risk of reducing a complex activity, such as instruction, to a set of mechanics, badges and score opportunities. There is also the concern about possible frustration induced to students with lower performance, or who may be somehow penalised by such an approach. Finally, the process should balance extrinsic motivation (rewards, games, trophies, cash, etc.) with intrinsic motivation. All these points are relevant and should be considered. We believe they should be faced through a good gamification process design and by stressing the role of the teacher/educator in managing the process execution [6].

## 3 Vision

In our vision, Serious Games will become a new, reliable tool for learning. Educators, trainers, consultants etc. will be able to exploit reliable information and services to select the most suited games for their specific needs and objectives.

Serious Games will be able to adapt contents and presentation modalities to the different user needs and preferences. This will be achieved thanks to an extensive use of accurate tools dedicated to the design, configuration/adaptation and use of Serious Games. The different educational strategies of the teachers will also be considered, allowing adaptivity also to different pedagogical strategies by different teachers.

A comprehensive framework of services (including learning analytics, dialogue management, virtual characters’ emotion management, etc.) will be available in a cloud, for efficient and effective development of Serious Games, featuring extensive interoperability. All the services expose an easy-to-use authoring tool, so that pedagogy and domain experts can easily include their knowledge into new instances of various Serious Game formats.

The new generation serious games will be able to provide compelling adventures set in highly realistic and information-rich environments, where quests/investigations can be solicited and experiments safely and accurately performed. Competition and collaboration will be supported in meaningful opportunities. This should lead to higher-order thinking, supporting research question, strategic thinking, interpretative analysis, problem solving, planning and hypotheses verification. Learner assessment will be accurate along several dimensions and in real time, enabling immediate (actually depending on the player needs and the educator's goals) and formative feedback. This represents a significant complement with respect to the current educational offer.

Several Serious Games will feature mechanics that favour physical-world interaction, with both other people and objects. This aims mainly at supporting human relationships, that are key for education, and at addressing the difference between fiction and reality. The link between the educator and serious games for education will be specifically targeted. It is important that Serious Games for education are able to support the basis of education, which generally means the growth of a person under the guidance and with the help of an adult. A different approach, of course, will characterise Serious Games for training, where the overall formative aspect (personal growth) is less ample.

Given their appeal, Serious Games will be used in particular in the leisure time, thus allowing people to learn or become aware of topics that they would have otherwise ignored.

Achieving all this requires not only the exploitation and development of advanced technologies in fields such as Artificial Intelligence, Human-Computer Interaction, modelling and simulation, neurosciences, virtual reality, etc., but also accurate and detailed studies on the design of game formats, mechanics and dynamics, that are able to effectively join educational and entertainment goals (a very difficult balance to achieve) in meaningful and compelling wholes (i.e., the actual Serious





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Games). This needs extensive user studies for verification of target achievement as well. Achievement of this vision is a complex long term task. The goal of GaLA and SGS is to create awareness of the stakeholders needs and of the state of the art of the supporting technologies; to indicate and shape the research directions in order to meet the requirements; and to structure and support the research activities at international level so to optimise their overall impact.

## 4 The innovation of GaLA

The structuring of Serious Games research activities requires that quite an ample field (involving several disciplines, ranging from psychology to computers, from pedagogy to game design) is covered, also considering a variety of aspects and stakeholders (from education to market, from industry to political decision makers).

In order to achieve these goals, appropriate methodologies and tools need to be studied, developed and adopted. GaLA is developing some instruments, in this regard, that we describe in the following.

A Virtual Research Environment (VRE), which is an online platform providing services to support Serious Games development, study and deployment. The VRE includes two major modules:

- the Serious Games Study Framework, which is a Knowledge Management System (KMS) based on Serious Games descriptions [13] in order to allow cataloguing, querying and data-mining, with visualization of analytics. The KMS aims at allowing experts to create a hierarchical network of entities (units of knowledge that we call Serious Games descriptors), that describe a Serious Games according to a predefined ontology. Descriptors involve texts, keywords and other multimedia assets for representing a Serious Games. Descriptors concern game elements and mechanics, game

design and implementation aspects, modalities of use of Serious Games, pedagogical principles. The entities can be linked among each other. Definition of links (e.g., among game mechanics, pedagogical principles or goals, development tools) is important to connect various facets of a complex multidisciplinary field. This approach, in fact, intends offering a global overview and supporting a connected exploration of Serious Games. Moreover, it should allow the capture, through appropriate data mining tools, of significant emergent patterns in Serious Games design and deployment.

- the Serious Games Service Catalogue, offering services that provide advanced functionalities for Serious Games. Sample services include: Natural-Language Processing for SG-oriented dialogues with Non-Player Characters; User profiling; Learner Analytics [16]; Emotion Management. All the services should come with an authoring tool, since involvement of pedagogy and domain experts (e.g., historians, geographers, etc.) is a major requirement for facilitating diffusion of Serious Games.

The VRE will be extensible in terms of services to be provided, possibly also by third parties. The expected impact concerns favouring analysis, assessment and efficient development of Serious Games.

Two theoretical frameworks have been developed and are now under testing:

- the learning and game mechanic (LM-GM) framework, that aims at mapping game contents (mechanics, narratives, etc.) and curricula contents and pedagogical goals [18]. The goal of this framework is to support Serious Games analysis (which is key for Serious Games selection in educational contexts) and efficient and effective design.

- The Serious Games Multidimensional Interoperability Framework (SG-MIF), an analytical framework aimed at supporting interoperability of contents and services for Serious Games.

Living Labs (LLs) are being established at selected sites, in a User-Centred Design perspective, in order to support appropriate development through user participation in requirements elicitation and testing/verification since the early phases of development. The GaLA Living Labs are the first dedicated to Serious Games, thus are expected to have a significant impact on the community as tools available to researchers and developers.

GaLA is also developing a roadmap for Serious Games research in the next 10 years. The work is ongoing and is based on an analysis of the state of the art by nine technical committees each one investigating a key area (Serious Games mechanics, AI, Human-Computer Interaction, architectures, assessment, psychology, pedagogy, neurosciences, interoperability & standards). The goal of the TCs is to provide a corpus of disciplinary knowledge related to the Serious Games domain offering a critical overview of the field trends and possible new opportunities to meet the requirements in several different application domains where Serious Games are applied. We have grouped the domains into six areas (safety, manufacturing, cultural heritage, health, ethics, business), each one of which is assigned to a Special Interest Group (TCs), with the goal to elicitate the requirements from each domain. Then, TCs and SIGs put their findings together and collaborate to identify business opportunities and technological gaps and trends in the various application domains and considering the various disciplines relevant to Serious Games development. Finally, a unified overall roadmap will be defined.



## 5 Conclusion

In the previous sections we have sketched the future that we would like to design and reach through our research coordination work. Achieving all this, in fact, will require not only the exploitation and development of advanced technologies in fields such as Artificial Intelligence, Human-Computer Interaction, modelling and simulation, neurosciences, virtual reality, etc., but also accurate and detailed studies on the design of game formats, mechanics and dynamics, that are able to effectively join educational and entertainment goals - a very difficult balance to achieve - in meaningful and compelling wholes. Recently, Connolly et al. [4] have shown that playing computer games is linked to a range of perceptual, cognitive, behavioural, affective and motivational impacts and outcomes. The most frequently occurring

outcomes and impacts were knowledge acquisition/content understanding and affective and motivational outcomes. Despite the diffused perception that games might be especially useful in promoting higher order thinking and soft skills, the literature review provides limited evidence for this, also given the lack of adequate measurement tools for such skills.

A fundamental aspect when analysing effectiveness of Serious Games with educational goals is their ability in assessing user learning performance [1]. Seamless (stealth) assessment [17] is a major research topic for building educational Serious Games able to meet their pedagogical goals, provide proper feedback and support adaptivity without interrupting the user's flow. We believe that this – together with proper design - is a key challenge for new generation games capable of joining attractiveness and instruction.

Achieving this target will need also extensive user studies for verifying the real impact and educational added value. This implies a long research road, that GaLA and SGS are committed to indicate, explore and shape.

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## CHAPTER 10

# Future Classrooms

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There is a complex relationship between the environment in which education takes place and the agency of teachers and learners.

Learning technologists make interventions in the environments of learning: in spaces, either physical or virtual. They hope that through these interventions the agency of teachers and learners will change in response (and in line with their expectations).



This rarely happens, as Heppell succinctly noted: “We should not assume that everything changes. By and large, children and learners do not change - there has been no ripple in the European gene pool as a result of new ICT” [6]. Despite this, however, the economic, social and political environment of the world has been transformed by technology. In this context, finding ways in which educational practice can address the demands of the knowledge economy and emerging markets remains a priority for European competitiveness.

Addressing the broad problem of change in practice, the **ITEC project** has sought a more diverse and nuanced approach to changing the agency of teachers and learners. In pursuance of this, technological intervention in the learning spaces of the classroom has been combined with community-building, and new means of coordinating pedagogical practices across the European partners in the project. The community and coordination aspects are important because, as a number of studies have shown [12, 8] sustainability of practice with technologies is more likely if those practices are not isolated from one another, but form part of a broader ‘community of practice’ [11].

ITEC has sought to establish a community of practice focused around specific pedagogical activities which in turn have implicated the use of particular technologies. However, the interpretation and rigorous testing which iTEC aspires towards necessitates some organisational criteria:

- a. there needs to be a way of ensuring that a standard set of activities are realised across a large range of learning contexts;
- b. there needs to be the means of ensuring that those learning activities and the technologies supporting them are made available across the project.

ITEC’s mission, therefore, has been to establish the infrastructure which satisfies these criteria, whilst at the same time building the community of practice which will benefit from this infrastructure being

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in place. This is an ambitious plan which seeks more than merely changing the environmental context of classroom practice, but putting in place an infrastructure whereby pedagogical and technical innovation is community-led and community-sustained. This is central to the iTEC philosophy: it is the means by which individual instances of classroom practice are connected and contribute to a broader effort in experimenting with new pedagogies and technologies. By doing this, the conditions for sustained innovation through engaging in new practice is not only a means to better practice on the ground, but also a means whereby teachers continue their involvement in a Europe-wide community of teachers the membership of which is something of perceived value to them.

The affordances of new technologies present new kinds of learning activity. Seeing the possibilities in new kinds of activity can be a powerful lever for change [2]. Indeed, with new kinds of activity and new ways of approaching pedagogy, new ‘spaces’ for organising



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learning become possible: for example, the use of outdoor spaces, or harnessing the affordances of virtual space for integrating outside experts, or other participants beyond the classroom. The experimentation with new affordances and new kinds of spaces has demanded innovative ways of provisioning tools for those activities. From this, this author sees three dimensions of significance in the project concerning the ‘classroom of the future’:

- Learning Spaces – where learning happens;
- Learning Activities – what is done and how;
- Organisation – how learning is coordinated and how instances of practice are shared.

These three elements are specified in the principal coordinating device of the project: the educational scenario.

## 1 The Educational Scenario

The primary function of the ITEC scenario is to attenuate the potential diversity of educational practice within the classroom onto particular foci. By doing this, the scenario provides a framework for comparative evaluation and assessment of pedagogic practices in a wide range of different contexts. Additionally, scenarios allows for particular explorations of pedagogical approaches which address deeper social trends which are identified as representing significant emerging challenges to the future of education.

Trend analysis conducted for the project has identified challenges ranging from increased learner personalisation and technological flexibility, to social trends such as increasing diversity within the classroom [3]. Generated scenarios based on these trends identified particular types of activities which involved the use of innovative technologies and explored new pedagogical approaches. Iterative

processes of review involving stakeholders identified those scenarios which would be most practicable for large-scale deployment within the project. These final scenarios then served as the focus of project activities in the pilot stages.

Whilst scenarios are broad-brush descriptions of learning situations, the learning activities they suggest form the focus of the activities that are coordinated in the piloting phases of the project. These learning activities have undergone further processes of elaboration and refinement in preparation for large-scale roll-out amongst the project partners. In support of some of these activities, new technologies have been developed. For example, a common need was identified for the support of group-based reflective activity. Consequently, a new tool was produced with the appropriate affordances built into it. Whilst not the case for all scenarios, such instrumentalisation of selected learning activities from the scenarios can also serve as a powerful coordination mechanism throughout the piloting phase [1].

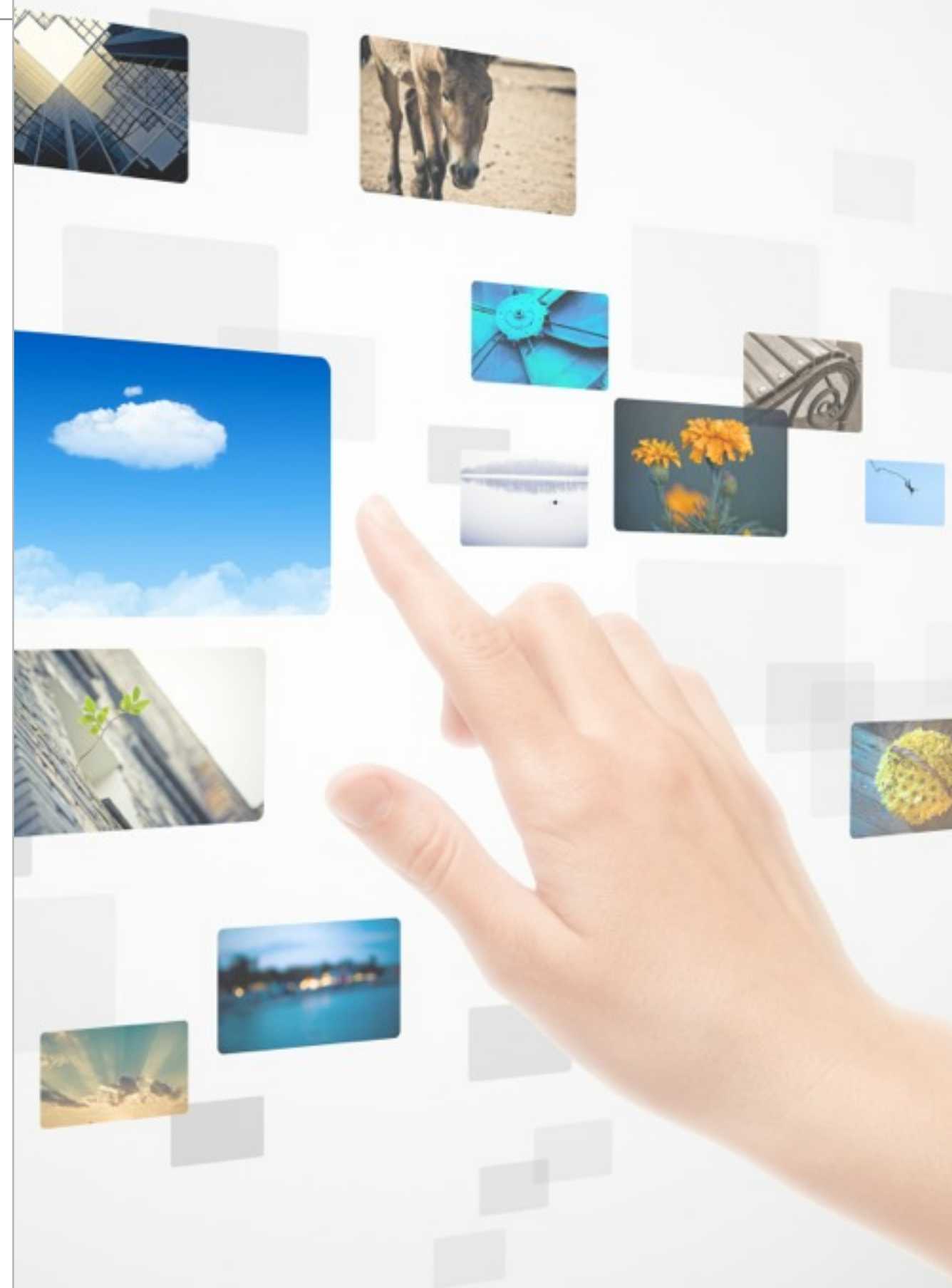
## 2 Spaces, Activities and Organisation

ITEC is concerned with the “Classroom of the Future”. The extent to which the ‘classroom’ of the future is considered a ‘space’ is something that has been directly addressed within a number of the scenarios that have been generated. The ‘space’ metaphor can be extended with the use of new technologies which facilitate new kinds of coordination of learning activity. Amongst the scenarios piloted, see [7], the scenario ‘A Breath of Fresh Air’ deployed technologies for the collection of data in the outdoor environment. Alternatively, the “Beam in the Expert” scenario uses technologies to expand the classroom boundaries by inviting external participants online.

The relationship between tools, resources and activities has long been an important issue in the design and description of technology-based learning [10]. The affordances of resources that are immediately to-

hand within a particular context presents possibilities for learning activities, whilst the desire to innovate with different kinds of activity drives approaches to re-tooling learning environments. In addressing long-term social trends that indicate ever widening diversity and specificity of learning needs, activities which invite new levels of personalisation, self-paced learning, and inquiry-based learning have been explored within the iTEC scenarios. Additionally, technologies have afforded opportunities for ‘flipping’ the classroom, with content delivery focused on the production of media, whilst classroom activities focus on group-based play and exploration.

For iTEC to succeed in its large-scale piloting, new means of provisioning and organising activities and technologies must be found. If this is not done, there is a risk that successes and failures become isolated and comparisons cannot be made. The organisational infrastructure of the project, whilst addressing the coordination needs of the project itself, also presents interesting possibilities for the future coordination of education across Europe. ITEC has education ministry-level participation across its partners. The promise of the project is to provide ministry-level coordination of innovations across different schools within the ministry’s domain. An educational scenario that can be proven to work well in one institution becomes easily instantiated in a different institution with different kinds of technologies. Deep coordination and sharing of knowledge, practice and innovation lie at the heart of ITEC’s aims.



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### 3 The Coordinating Framework

The coordinating framework of the project can broadly be described as comprising:

1. A stakeholder-driven process of educational scenario creation;
2. A technical infrastructure facilitating easy deployment of ITEC technologies which support the delivery of scenarios;
3. Technical tools for teachers to specify technological solutions and to seek technical recommendations for pedagogical challenges in scenario learning activities.

The technical support of the scenarios has been approached in a variety of ways. The scenarios themselves have been the focus of community engagement, with a wide range of technical solutions possible for effective realisation. With commercial partners within the project who already have at their disposal mature classroom technologies (Interactive White-Boards), the realisation of scenarios has provided an opportunity to deploy some of these technologies within the classroom and to explore the pedagogical aspects of the scenarios in this way. In other cases, simple technologies like Wikis have provided easy ways in which many of the technical challenges identified in the learning activities of the scenarios can be met.

Each potential solution to addressing the needs of an educational scenario can be collected using ITEC's 'Composer' tool, which can map pedagogical requirements to technical recommendations that are suitable for a particular institution. This means that classroom practice may be codified, shared and critiqued, creating a foundation for reproduction and large-scale deployment, together with the possibility of iterative improvement in pedagogical practice. Semantic information concerning the affordances or 'functionalities' of tools, the technical requirements of learning activities and the technological infrastructure of individual institutions can also feed into a recommendation system

that can assist teachers or local technical administrators to deploy appropriate tools to meet the requirements of a scenario within a particular institutional context.

The deployment of tools to meet the pedagogical requirements has demanded flexible ways in which toolsets can be organised and distributed. The use of 'widgets' (small web-based applications) has formed a key component in the technical architecture of the project. These tools can be instantiated across a wide range of electronic learning contexts, including a number of popular Virtual Learning Environments. Widgets can provide the requisite affordances for many of the scenarios, and their development together with the creation of a 'widget store' has been a parallel task running alongside the early piloting of scenarios. The Widget Store, based on the Apache Wookie Widget Server [5,13] provides an online facility whereby teachers can aggregate and curate different tools for deployment in their teaching. The store also provides additional social network features, thus not only serving the instrumental purpose of delivering tools, but also providing a means whereby the teacher community may share and comment on widgets which they find meaningful and useful within their practice.

By providing ready-to-hand tools which are easily instantiated in different contexts, the Widget Store extends the basic principles of the Personal Learning Environment, whereby teachers can aggregate and instantiate the toolsets they are comfortable with, rather than having standard centrally-controlled or proprietary toolsets forced upon them. In effect, the Widget Store provides a 'personal teaching environment' for teachers: providing them with their own toolbox which they can carry to any learning context.



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## 4 Methodological Challenges: from sense-making to sustainability

The essential challenge that ITEC faces is one of identifying patterns of pedagogical practice which work, understanding the contexts within which things can be seen to work, and reproducing instances of successful practice in different contexts. “Success” here involves a number of factors ranging from teacher adoption and enthusiasm for the aims of the project, the effectiveness of particular tools in realising learning activities and the meaningfulness, appropriateness and effectiveness of particular scenarios.

Since ITEC amounts to more than simple ‘environmental interventions’, activities of sense-making and critical review of the pilots represent an important opportunity to compare and examine educational practice across Europe. With education forming a fundamental component in EU-wide initiatives to drive European innovation in the knowledge economy, ITEC’s focus represents an opportunity to assess educational practice and examine new models of coordination across the school sector.

ITEC is an ambitious project. As an ‘Integrated Project’ of the European Commission its fundamental focus is practice: it aims for the large-scale piloting of innovative technologies and educational practices within 1000 classrooms within the European Union. This presents great complexity which the project needs to manage. The risks the project faces with regard to its sustainability are great: ITEC must conduct its piloting in a way where meaningful comparisons can be made, whilst successfully engaging in community-building so as to maintain levels of enthusiasm and support from teachers. Without an effective community of pedagogic innovators, it is unlikely that the impetus for the use of new technologies can be maintained. Without effective technological coordination of the project, the maintenance of the community and the coordination of its activities cannot be

effected. Finally, without easily-instantiated tools which are usable in different contexts, the scope for meaningful shared discourse about learning activities in different contexts is compromised.

## 5 Conclusions

At the time of writing this chapter, ITEC is just over half-way through, with a number of pilots already having taken place, and with the completion of the technical infrastructure of the project (which has been developed in parallel with the pedagogical programme). The next stage of pilots will be the first to explore the affordances of the ITEC technologies in realising the scenarios across Europe. The introduction of new tools in highly diverse technological and pedagogical contexts across Europe presents organisational, pedagogical and technical challenges. Yet these challenges provide a unique opportunity to examine the school sector across Europe, using the scenarios and their associated technologies as the basis for the establishment of new networks and communities of practice across the continent.

The issue of the “Classroom of the Future” reflects a number of concerns about the role and nature of education in the development of the knowledge economy in the future. For Europe to compete globally with the emerging challenges represented by increasing global competition, it will require education that inspires creativity, independence of thought and entrepreneurialism, whilst instilling core social values of cooperation and openness across boundaries. If the “classroom of the past” focused on the instilling of knowledge and skills in preparation for participation in the industrial society, the “classroom of the future” focusses on realising individual human creative potential. ITEC’s ambitions represent an important intervention in the integration and coordination of a European education system which prepares its citizens for the challenges to come, so that they might live lives that are prosperous, peaceful and meaningful.

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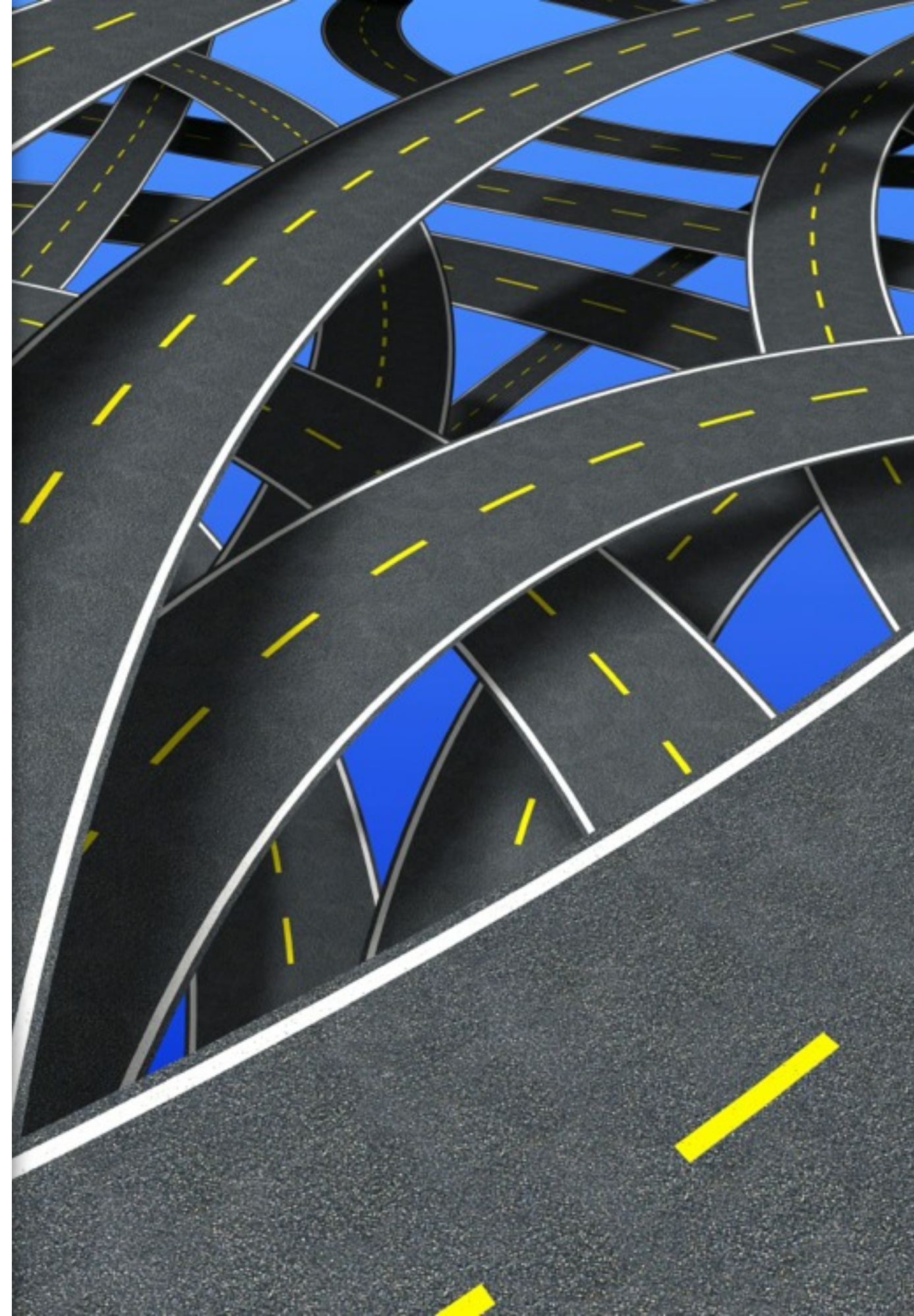
## CHAPTER 11

# Adaptive Roadmapping

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Innovation in technology enhanced learning is a complex process which is more likely to happen in a planned way (a ‘desired future’) if various stakeholders co-ordinate their activities in an ‘innovation eco-system’ to bring changes. The TEL-Map Project has developed a process for ‘adaptive roadmapping’, with roadmaps to achieve the desired future for technology enhanced learning being created by participants in such a system for them to coordinate their activities moving forward and to review and adapt in the light of changing circumstances.





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Two clusters (innovation networks or ecosystems), which include innovators, researchers, technologists, and practitioners, have formed to pilot and reinforce the roadmapping methodology and process. The UK Higher Education (HE) cluster which looks at a desired future where ‘students are fully engaged in a variety of contexts’ to realize their personal, professional and social aspirations; and the Europe-wide Schools Cluster focusing on ‘The Creative Classroom and Changing Schools’ to address the massive changes required to participate effectively in society in the future. Each cluster’s shared visions, context scenarios and roadmaps developed by its participants are made public on the TEL-Map platform for others to engage with by commenting and contributing and potentially joining and actively working with the cluster.

## 1 Introduction

Innovation in a complex area such as TEL is increasingly being seen as an innovation ecosystem with multiple dependencies between players; players need to co-ordinate their efforts to manage their interdependencies in ways that can bring about successful change [1]. A coordinating loop needs to be established between users, providers, funders, researchers and developers, in parallel co-innovation efforts and sequential development.

Those perspectives are at the heart of the TEL-Map project, which is funded by the European Commission to enable stakeholders to establish their shared desired future, share their insights on past and current TEL and forward thinking on TEL futures and develop appropriate roadmaps collaboratively, then work towards actually bringing about the desired futures for TEL in Europe.

Combining the widely adopted Future Search [2] and scenario planning methods derived from the well known Shell/SRI approaches [3,4], integrated with participatory observatory techniques, the TEL-Map

project has developed an Adaptive Roadmapping method, which seeks to overcome the limitations of earlier European TEL roadmapping projects where “experts” produced roadmaps that were arguably not followed by others or were rapidly outdated by changing circumstances [5]. In contrast, the TEL-Map approach seeks to support clusters of mutually dependent TEL actors with a shared concern or area of interest, whose participants already have a responsibility for moving it forward and between them have the resources, skills, authority, knowledge and need to bring about their chosen innovations. Initially, the UK HE pilot cluster and the EU Schools cluster have been formed and within those clusters the participants have been working together to create their visions, desired futures and roadmaps for future TEL in education.

## 2 The Methodology of Adaptive Roadmapping

TEL-Map Adaptive Roadmapping brings together and integrates a number of existing futures-oriented approaches, including Disagreement Management [6], Future Search, Scenario Planning, Roadmapping, Weak Signals, Horizon Scanning, Delphi, Trend Analysis, Gap and SWOT Analysis (The Millenium Project, Futures Research Methodology Version 3.0 - a compendium of futures methods provided on CD, see [7]). It aims to turn them into a continuous, dynamic process that actively engages and supports stakeholders in their TEL-supported desired future, taking it through to adoption in practice.

TEL-Map seeks to work with and support stakeholders in the area of Technology Enhanced Learning (TEL) to develop better, more effective and more widely adopted uses of technology that make a significant difference to the processes of learning. However this is a complex task, with many different players involved who need to understand

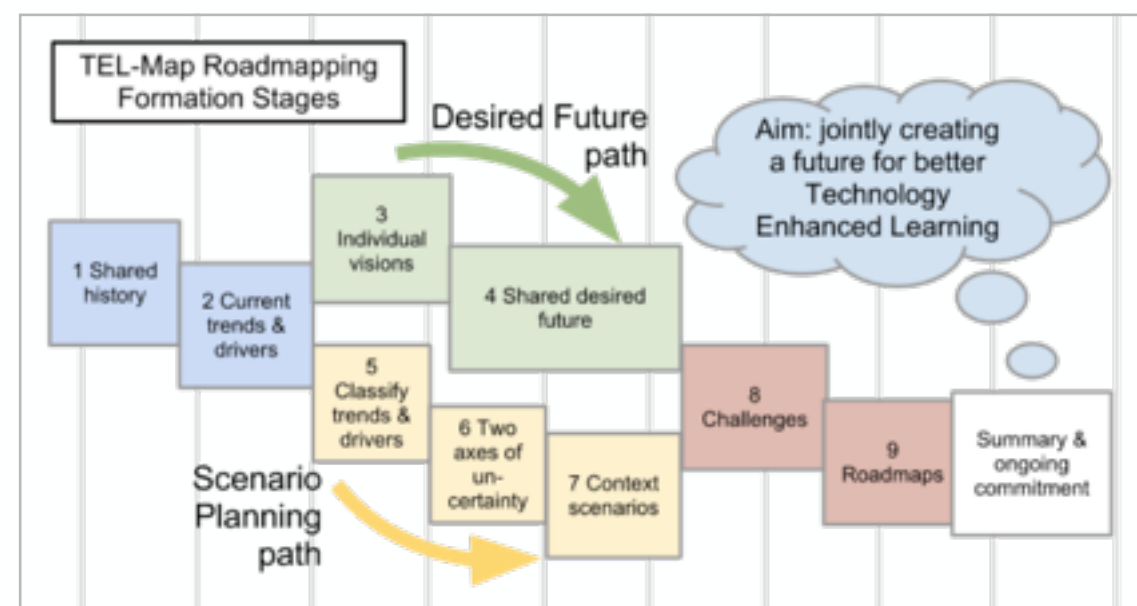
each other, their respective goals and problems. For this to scale, the TEL-Map support project plans to identify actual and potentially collaborative clusters of stakeholders, researchers, developers, producers, software and content providers, decision makers and users, who between them hold all the keys that are needed to articulate and bring about these changes.

For the TEL-Map project to support these clusters however, a prerequisite to developing such a Roadmap is supporting stakeholders in the task of agreeing on a shared desired future. We adopted an acronym from Future Search for identifying the key stakeholders in the innovation ecosystem, ARE-IN, those who have:

- Authority to act: People with a responsibility for the future development of education in general and, where they are in post, for TEL in particular, e.g. those from Ministries of Education.
- Resources needed to implement plans: These will include funders; the directors in TEL-related companies and budget holders who are responsible for the purchase of TEL in schools, universities, and private education providers.
- Expertise in the issues being considered: They will mainly be educationalists, pedagogists, researchers and developers who are TEL-focused, ICT-focused and learning-focused.
- Information about the topic that no other groups have: ranging from those with detailed knowledge of the use of ICT in various sectors, e.g. in Ministries of Education, Marketing Directors in TEL product and service companies, people in agencies that support TEL, such as EUN SchoolNet or CETIS.
- Need that is being addressed: This will be those directly involved in learning and teaching, i.e. learners and teachers in schools, universities, commercial and government training providers, both in-house and commercial training providers.

In order to involve various ARE-IN stakeholders in the roadmapping process, four clusters have been formed, two ecosystem groups, the European School cluster and the UK HE cluster, and two supporting groups (the Industry cluster and the Research cluster) aiming to produce more traditional sector and policy roadmaps. Each cluster has a different focus, different ways to manage the process and different types of outputs. For example, for the European school cluster and HE cluster, participants were invited to work individually or collaboratively to complete the tasks step by step via either online or face-to-face meetings. There are four tasks, which have been carried out with these collaborative clusters in parallel:

- Mapping the current TEL domain and working with the clusters to map their specific domains
- Working with the clusters to develop Desired Futures
- Working with the clusters to develop Future Context Scenarios
- Considering the outputs from above tasks and producing Roadmaps.



*Figure 11.1 The TEL-Map roadmapping process.*

Figure 11.1 illustrates the process and tasks undertaken by the clusters during the face-to-face and online meetings to produce their initial roadmaps. In this chapter, we will report the shared vision, context scenarios created by the European School cluster and UK HE cluster.

## 3 Perspectives from the UK Higher Education innovation network

### 3.1 The Shared Vision for UK HE

The overarching theme for the UK HE was: “Students fully engaged in a variety of contexts”, with a focus on using social media to enable students to engage in these different contexts. Around this theme, a Shared Vision was developed with a future where students:

- are fully engaged with their learning, with the university, with each other and with the wider local community through the practical application of their learning
- can self-organise into safe social learning groups with control and suitable granularity
- are supported by a ‘social media infrastructure’

In order to realize the shared vision, six principles have been identified:

- Transforming student experience towards full engagement.
- A learner-centred design for higher education. This places the responsibility for managing learning on the learner, and is clear about expectations of all participants in terms of duties, timelines and criteria.

- All stakeholders are co-learners, with effective strategies to enable building a strong identity, a clear sense of place, ownership and of belonging to a real academic community.
- Institutions willing to work together to create exemplars of learning in disciplines, through the use of open educational resources and open educational practice.
- The diversity and range of student experience is recognised. Therefore diversity of provision is needed to cater for different individuals’ aspired futures.
- All students supported to realise their personal, professional and social aspirations.

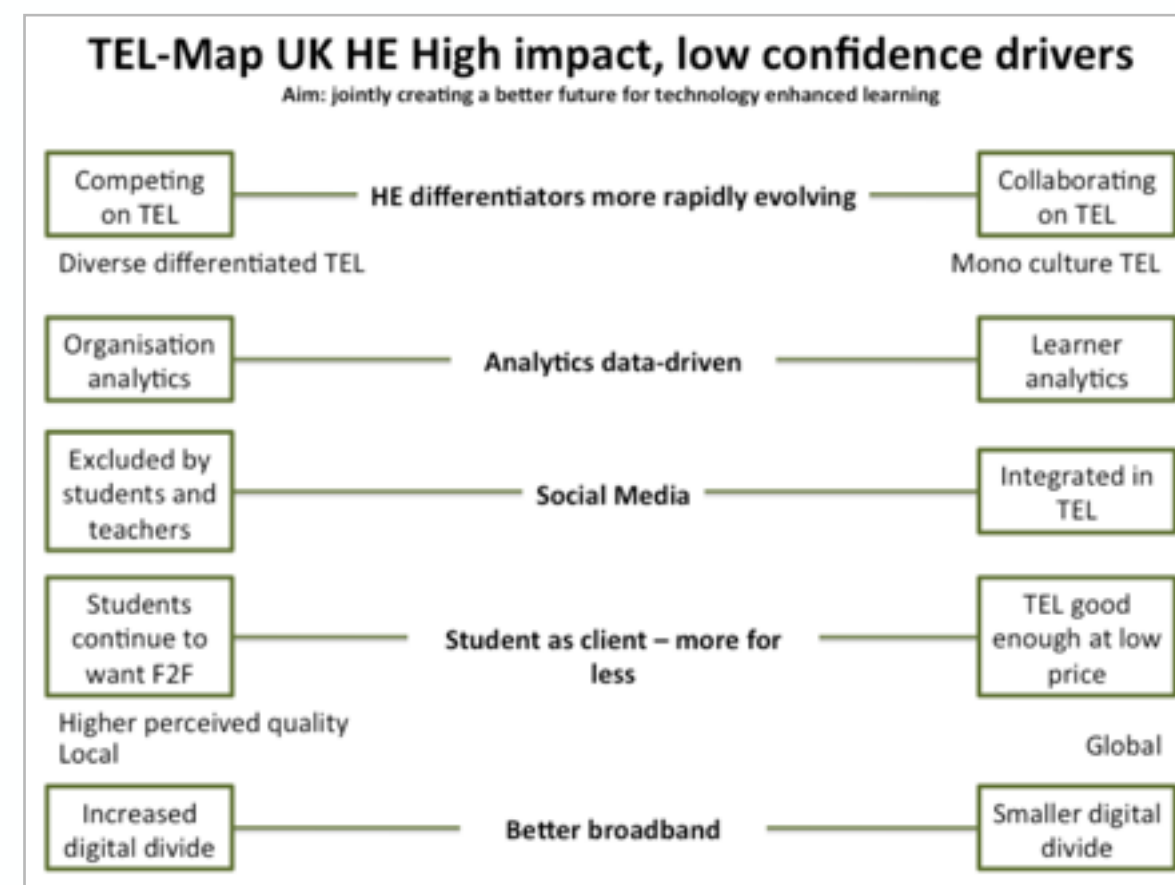


Figure 11.2 Drivers identified for UK HE.



Their Shared Vision is seen as being integrally supported by a range of technologies (desktops, portables, mobile/smartphones, tablets, linked through personal, local and wide area networks). The technology is harnessed to help students build a sense of community or belonging ('habitus') during their time at university. Learning technologies are becoming central in HE environments, supporting learning in all contexts. For example, providing an open learning platform to support interdisciplinary, flexible and individualised learning in HE. Learning set-ups where CMC is facilitated, and formal and informal learning are embedded/combined through the use of social media. It is also important to seek a compromise on the division between the information that the University needs to monitor in order to ensure its own effectiveness and the information available on the Internet that is useful to learners but is disconnected from the University system.

### 3.2 Future Context Scenarios

The process of developing future context scenarios involved brainstorming trends and driving forces that are impacting on TEL in HE. These were then rated for impact and then for confidence in their direction or persistence. The driving forces, which the group judged to have highest impact but lowest confidence, were identified and then clustered into two 'axes of uncertainty'. These two axes then formed four quadrants of a 'field of uncertainty' about how relevant aspects of the wider context might develop in the future. The following five emerged as key factors with high uncertainty.

These high-impact, low-certainty factors were then condensed into two mutually independent 'Axes of Uncertainty'. The two axes arrived at then were:

- Convergence or Diversity
- F2F or Online

Using these axes, they went on to create a four-quadrant grid of possible future Context Scenarios that capture a range of uncertainty about important aspects of the future in which universities will find themselves operating. The corners of the resulting quadrant suggested four resulting scenarios (see [Figure 11.3](#)):

- *Traditional University*: In this possible future context scenario, today's campus-based universities continue into the future on basically the same face-to-face (F2F) model as at present. Technology is used to enhance the basic model but does not change it. Rather the more tacit knowledge and learning, including the social aspects are more clearly seen as key values that the degree certificate also signifies.

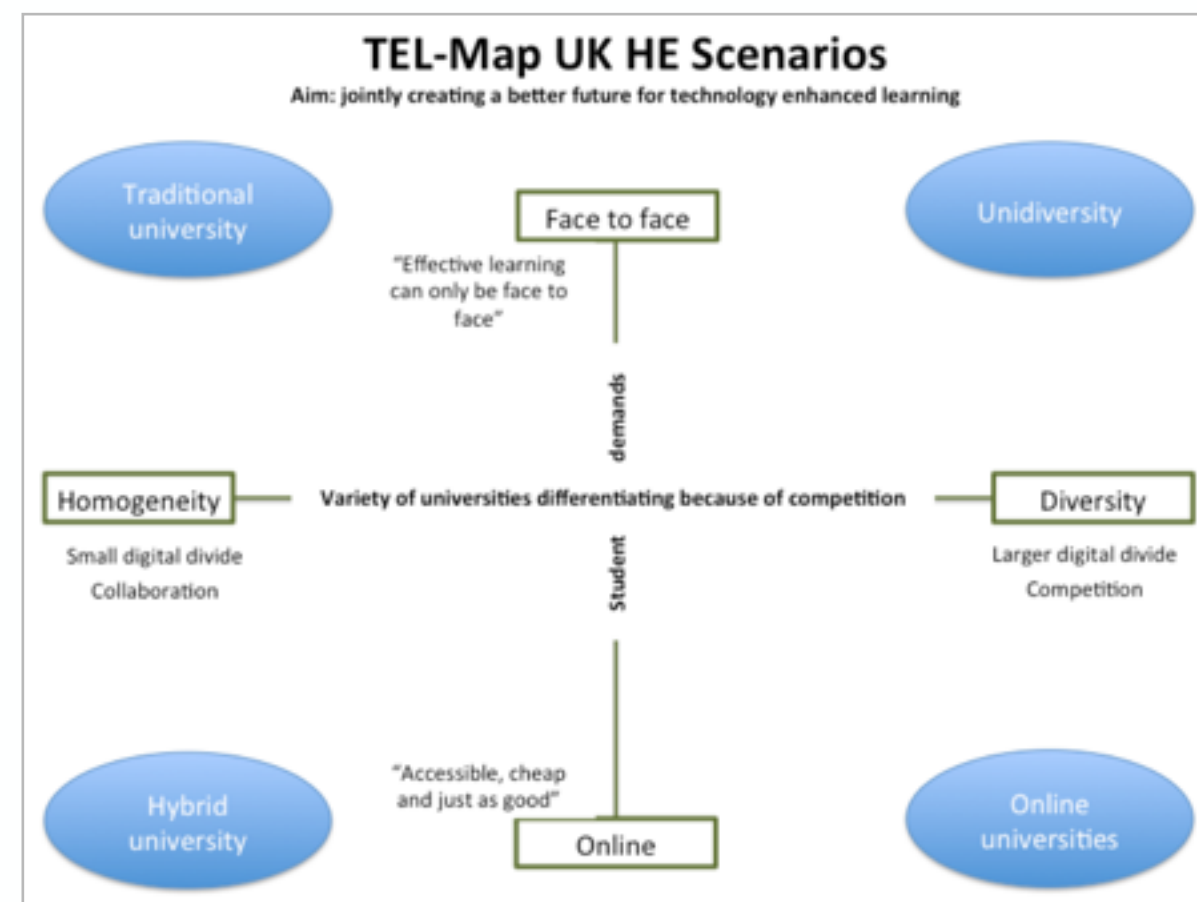


Figure 11.3 TEL-Map UK HE Future Context Scenarios.

- *Unidiversity*: In this possible scenario, while the benefits of F2F learning and teaching are still recognised as paramount, it is equally recognised that the Oxbridge ideal of a personal tutor, is hugely expensive and only available to the wealthy few. For the majority of students, different paths will need to be found, but these will be different routes towards the ideal. Technology is seen, not as replacing, but primarily supporting a wide variety of F2F engagements, giving rise to a wider variety of enhanced forms of learning.
- *The Hybrid ‘De-Campus’ University*: In this scenario, the economic pressures of similar or reduced budgets, coupled with greater expectations from students now paying 3 times more in fees, drives universities on a path to a much more intensive use of ICT to support learning. In the extreme, due to high overheads, this could lead to most universities ‘de-camping’ and largely moving to online provision as a set of variants on the UK’s Open University model.
- *Online Universities*: The same drivers as the De-Campus scenario, increasingly move provision online, but in this scenario, competition between universities, with increasingly differentiated and innovative uses made of continuously enhanced underlying technologies, result in creating a wide variety of online university provision. This ranges from, at one end, students undergoing largely independent study, using OERs to provide essentially free courses, with paid-for external examinations and degrees awarded when students feel ready. At the other extreme, some universities may make full use of the development of interactive social technologies to provide close personal support for students - but with a far lower price tag than F2F personal contact.

### 3.3 Using the Roadmap

At the current stage of the project, it has just begun to map the initial roadmap into the four context scenarios to identify changes that may be necessary to the roadmap in each eventuality. This marks the end of the first stage, and forms the basis for the next dynamic or adaptive roadmapping stage (see [Adaptive Roadmapping in Action](#)).

## 4 A shared perspective for Europe’s schools

The aim of the EU Schools’ cluster is to support the implementation of the Europe 2020 call for enhanced Creative Classrooms, or now more broadly Creative Learning Environments, through bringing together and coordinating an ecosystem of interdependent innovation stakeholders working in the schools context. This cluster works to generate a roadmap based on their shared desired futures representing the intersection of their existing goals and activities. The aim is to find common ground in roadmapping the systematized introduction of creativity into European schools. The cluster is driven from the point of view of implementation, seeking to bring the “whole system” together in a group. This includes a critical mass of participants in order to tackle, resolve and plan solutions for the Creative Learning Environment and supporting TEL systems that could not be achieved by individual actors working alone.

### 4.1 Connected Open Community Schools for Change

Empowering learners in the ecosystem involves teachers, parents, suppliers and society. This means empowering learners to draw upon influences and resources and utilise that knowledge to develop in an



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ecosystem that can either be self-perpetuating or complementary to a wider global network. Also it means empowering those who can help learners (both at a cost and for "free") through openness:

- Collaborative learning, seamless and integrated with society
- Learning with and from the environment, community and business worlds.
- Strategies for negotiated Curriculum and Assessment, adapted to the Learners' needs.
- Enabled by open, readily adaptable practices and resources, together with open values and ways of recognising quality in learning and empowering all to participate in agenda setting, curriculum, learning strategies and assessment, etc. School as trusted open learning environment connected to the local community and beyond.

This Shared Vision was emerged from six initial visions developed by different groups, these are:

#### **Vision 1: Beyond the schools**

The classroom of tomorrow will be a blended learning space made of physical space and virtual space. Technologies like augmented reality, gesture-based, cloud and mobile will support the virtual space definition and management. The classroom will be a distributed and mixed ages class, not limited to students but extended also to parents and other adults. Collaborative tools (e.g. social networking) will support the learning activities. Technology will support the individualized profiling and the students' data protection. Individual profile will contain life-long story-telling data, which can be used to negotiate the learner's learning and can be shared with others.

Learners will have access to distributed learning material (repository of knowledge) likely shared by other institutions. Learners will participate

in the generation of contents. Teachers and personnel of institutions are continuously training in the use of new learning technologies.

#### **Vision 2: ISP SOLVER (Individualization, Socialization, Professionalisation) - Shared, Open, Learning, Values, Environments and Recognition**

The main driver in this vision is to “achieve balance between individualization, socialization, and professionalization” by creating seamless learning environment. Increase learning variation in terms of personalised learning paths/portfolios and Variety of assessment methods. Schools to be open to society, parents, researchers, local community, breaking down the boundaries between school, parents, teachers, employers, etc, via the use of technologies (e.g. a tablet, a social group) to link and elaborate what happened at school to home etc. High quality learning and education should be public goods and free for the public

#### **Vision 3: Learning to be a change maker**

The core idea in this vision is to use learning to become a change maker. Learning will be around identifying a real world dilemma and using the Internet to gather relevant information and working with peers and others outside the school to find a solution, as well as managing the change process and dealing with different viewpoints and challenges. Students feel that they have ownership of the school, they are fully engaged with subject matters and working collaboratively with others by connecting with other communities: family, neighbourhood/city, village, town, etc. Teaching about values of yours and others, in their social context: Transversal competencies and the school is the experimental social network lab for learning how to work in the larger social network.

#### **Vision 4: Local expanding to global school (add "open")**

The key idea here is to make the time that children spend in school really count. Technology can have a powerful role to support new



forms of learning, in term of migration and mobility to bring virtual, physical and social together. Teaching is standardised (e.g. Finnish common core curriculum), but multiple pathways (of teaching approaches/methods, technology chosen by school & teachers). Teach successful learning strategies, for whatever media you are using (e.g. teach how to learn with ICT) to help children become involved and engaged. Learners build their self-efficacy to be able to participate globally and locally, and to be curious about things around them and develop skills to deliver outcomes within expected time and quality criteria. Teaching profession highly-valued within society and teachers will challenge and motivate learners. Teaching profession will need to have cross-disciplinary knowledge and research, professional development skills, etc.

#### Vision 5: Seamless Learning

‘Seamless learning’ is across formal, non-formal, and informal through ‘collaborative learning’ activated in and out of the ‘connected’ school of 2021. International collaborations can be implemented through online collaborations and educational visits to provide seamless learning experiences for all pupils in the schools. Seamless integrated formative assessment to promote self-awareness of learning path/ achievement for all pupils. Teaching and learning to be guided less by standardized assessment, and more by more formative kinds of assessment. New forms of assessment are developed to assess new competences. Teachers and pupils to be ‘producers’ of content and knowledge, rather than being confined to the role of ‘reproducers’.

#### Vision 6: Whose agenda?

In this vision, the notion of teaching has changed and learning affordances are embedded in spaces. Technology as an enabler of making choices throughout a school day; technology creates necessary contexts needed to learn in an applied way, resulting situation is engaging and stimulating, introducing passion to learning by allowing children to follow their immediate interests, more applied

and contextualised learning objectives and the role of teachers is to link into on-going learning activities. Learners set the agenda and teachers follow (recognising and facilitating). Assessment needs to be feasible.

## 4.2 Future Context Scenarios

The schools’ cluster also brainstormed the drivers that would change the context of introducing or using creative learning environments, then ranked them by importance or impact and certainty of direction. The participants chose the most important and uncertain and attempted to group these and find two dimensions of uncertainty. In this case, two key axes of uncertainty emerged:

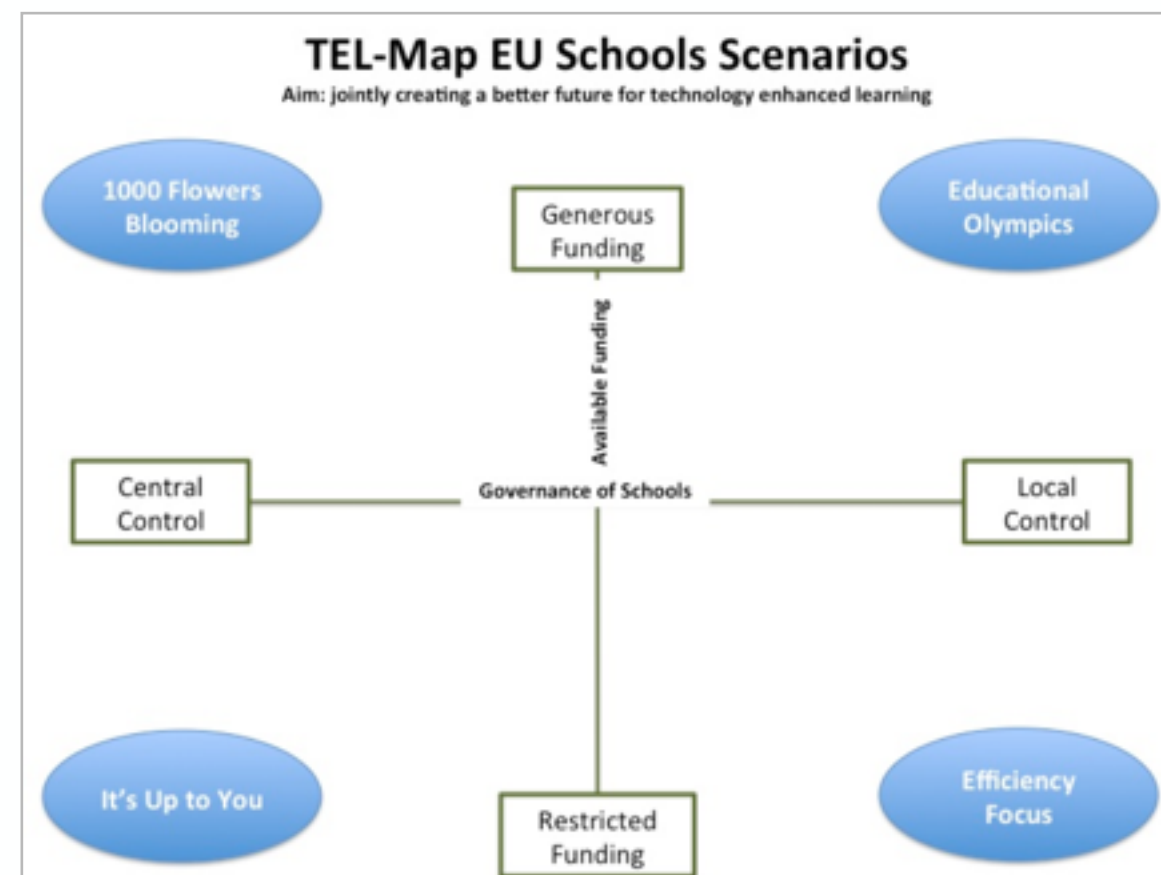


Figure 11.4 TEL-Map EU Schools’ Future Context Scenarios.

- Uncertainty about the economic situation and its evolution, which for European schools was translated as Available Funding: Would it be Generous or Restricted?
- Will governance of Schools come under central control or will it be decentralised and local?

This in turn gave rise to four possible scenarios that taken together, can characterise the field of uncertainty about the future conditions under which a Creative Learning Environment programme may have to be implemented.

- *‘1000 flowers blooming’*: Schools in this segment are generously funded, whether publicly or privately or some combination of both, but also have significant local autonomy over the school’s curriculum and management. Governance might involve the local community or might be by a local private company. They can be said to have ‘Enabled Bottom-up identity / power’.
- *‘Educational Olympics’*: In this segment, there is generous funding for the school system, but a high degree of centralised control. Curriculum, examinations, inspections, and even rules of governance and management are laid down by a central authority, whether government or a large private corporation. This arrangement can be described as ‘Enabled Top-down identity/ power’.
- *‘It’s Up to You’*: In this segment there is restricted funding available to schools, but there is a degree of local autonomy as to how that funding is used and the type of curriculum and activities engaged in. This might be called ‘Constrained Bottom-up identity / power’.
- *‘Efficiency Focus’*: Here there is restricted funding for the school system, but it is still centrally controlled, typically by government,

but possibly by a large commercial corporation. Whichever one, it is engaged in heavy cost-cutting - or there was simply little funding available in the first place. This can be referred to as ‘Constrained Top-down identity/power’.

### 4.3 Using the Roadmap

As with the HE cluster, the current stage of the project has begun to map the first draft roadmap into the four context scenarios to identify changes that may need to be made to the roadmap in each eventuality.

However, given the diversity of cultural, educational and governance approaches across Europe, a new twist has been added to the use of context scenarios. The four scenarios can also be used to map some key aspects of this diversity as it now stands, as well as how it may develop in the future. This need for accurate mapping (of what is happening now and what could happen) has always been a significant problem for the European Commission in its efforts to diffuse the benefits of funded education projects. Initial as well as continuing adaptation of innovation roadmaps will allow different approaches to implementing Creative Learning Environments tailored to different educational contexts.

## 5 Adaptive Roadmapping in Action

A key feature of this approach to innovation roadmapping is that it is a continuous process that responds to changing contexts. To support this there is an observatory and horizon scanning function, which as well as providing its own scanning, acts to co-ordinate and share the scanning activities of the various stakeholders in the cluster.

To initiate the transition to the dynamic or adaptive stage, the cluster passes to the Observatory its desired future, its roadmap and its context scenarios. These highlight the critical features to be developed along with the support software and technologies that will need to be developed. Equally important will be the uncertainty drivers that form the axes of the four context scenarios, together with suggested signs and signals that would indicate the actual direction in which these uncertainties are panning out. This in turn alerts the group to the appropriate variation, represented as a fork in the roadmap, to follow.

However the Observatory also provides alerts to other changes that might accelerate or hinder progress, feeding this back to the innovation cluster. The cluster then reviews this to decide whether their roadmap, context scenarios and/or shared desired future need to be modified, or in the extreme case, the project abandoned as no longer viable.

## 6 Conclusion

In contrast to other roadmapping approaches, the TEL-Map adaptive roadmapping approach seeks to make explicit and manage interdependencies between stakeholders as it brings together a network of key stakeholders to develop a shared future vision. The stakeholders have between them the knowledge and resources to actively follow their roadmap to bring its coherent set of innovations to fruition. Two active clusters have been formed, one in UK HE (pilot) focusing on 'the Happy Student' and its multiple aspects, and a larger EU Schools' grouping focusing on 'Creative Learning Environments and Changing Schools'. There are many cross links between the roadmap being developed by the TEL-Map clusters and the grand challenges identified in STELLAR, in particular, in the areas of learner engagement, massive collaboration and awareness (Analytics). The issues raised in the process of TEL-Map clusters in creating and

actively pursuing their shared desired futures and roadmaps offer new avenues and subjects for future TEL research. The desired futures and roadmaps produced by the clusters will be uploaded to the TEL-Map portal to be shared with the TEL community internationally and continue to be developed by relevant adopters in various contexts with different educational systems.

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## CHAPTER 12

# Acknowledgements



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